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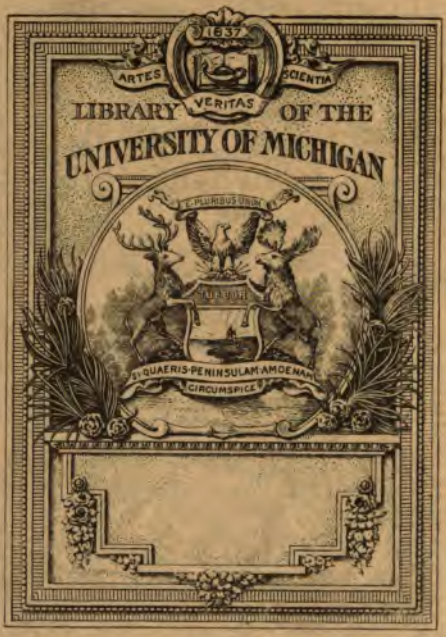

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STATIC, HIGH FREQUENCY, RADIO, PHOTO AND RADIUM THERAPY,

BY

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PREFACE.

This work covers the subjects given on the title page only, and does not claim to be a complete treatise on Electro-therapy. Two editions of ELECTRICITY IN MEDICINE AND SURGERY by the author were exhausted within three years of the first publication, and instead of publishing a third edition, the author has thought best to give to the profession a more complete treatise than could be given in a general work on those subjects that are to-day so much in the minds of both the profession and public, and which are establishing a permanent place in therapeutics.

It has been the endeavor of the author to keep this work within the limits of conciseness, especially adapted to the use of the busy man, and there has been no attempt to include all that has been written on the various subjects herein treated.

The author believes he has taken a very conservative position, and the statements made in the following pages can be fully relied upon.

New York, April 20th, 1905.

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ELECTRICITY.

CHAPTER I.

PHYSICS—STATIC ELECTRICITY.

Static Electricity.*—The term static signifies in rest, and electro-statics deals with the phenomenon of electricity at rest, or held at rest by forces acting upon it; this is in contradistinction to dynamic electricity, which term signifies that the current is constantly flowing along the conductors.

Electricity by Friction.—If a glass rod be rubbed with a piece of silk, and a pith ball suspended near it by means of a silk thread, the ball is at once attracted toward the glass rod (Fig. I). This is due to the electrical state or condition of the glass, produced by the friction of the rubber.

Electrical Attraction and Repulsion.—If a piece of thin metal be suspended near the glass rod by means of a silk thread so as to insulate it, the rod will attract the metal as it did the pith ball, but on contact just the opposite occurs (Fig. II); the glass will be attracted toward the metal until they touch; then, if the experimenter holding the glass rod be thoroughly insulated, the metal will be repelled. This

*This chapter is taken, with some revision, from the work on Electricity in Medicine and Surgery by the author of this treatise.

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shows that the power of attraction and repulsion is not exerted by the electrified body alone, but that it may be itself attracted and repelled by non-electrified bodies held near it. So long as a non-electrified body is near an electrified body it is attracted and also attracts the latter, but as soon as they touch and the non-electrified body is electrified, they repel one another.

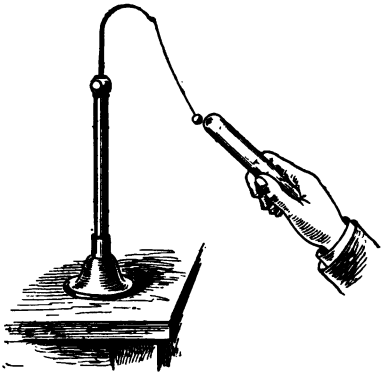

FIG. I.

The fact that a non-electrified body becomes electrified by contact is proved when another non-electrified body is held near it, and, proper precautions having been taken to insulate it to prevent the escape of the electrical charge, it is attracted and repelled in the same manner as when the electrified glass rod was used.

Electrified bodies, however, do not always repel each other, for if a stick of sealing wax be rubbed with a woolen cloth, and presented to an electrified body which has touched and is consequently electri-

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fied by the glass rod, they attract each other; or if the stick of sealing wax and a glass rod, after being excited by rubbing with silk, be suspended by silken threads, they will attract each other, (Fig. III).

This phenomenon of attraction and repulsion was first thought to be due to two kinds of electricity, described as two electric fluids, and it was believed that bodies electrified by the same kind repelled each other, while bodies electrified by different

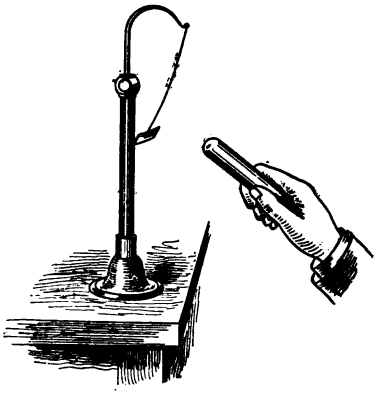

FIG. II.

kinds attracted each other. The supposed different kinds of electricity received different names; that produced by rubbing glass with silk was called vitreous electricity, and that produced by rubbing with wool, sealing wax, shellac and some other substances was called resinous electricity. These terms were based upon the erroneous supposition that no other kind of electricity could be produced on these substances, but it was afterwards dis-

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covered that if glass was rubbed with a cat-skin it produced resinous electricity, and resin yields vitreous electricity when rubbed with an amalgam of tin and mercury spread on leather.

Positive and Negative Electricity.—Franklin suggested the one fluid theory, and also in place of vitreous and resinous, the terms positive and negative electricity to distinguish the two electrical states, and they are still in use. These terms were derived from the theory that all objects possess a certain amount of electricity, and that a body charged posi-

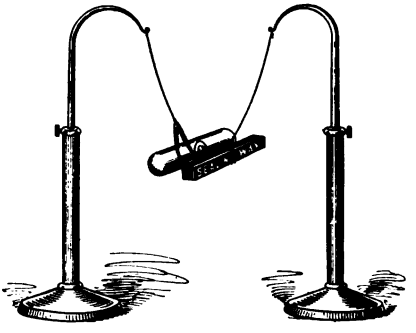

FIG. III.

tively and then known as vitreous electricity, as a glass rod rubbed with silk, possesses a greater amount than when in a normal state, and that a body negatively charged possesses a less amount of electricity than when in a normal state. From this supposition arose the signs which are still used to designate the two electrical states or poles of the battery, the plus sign (+) for the positive and the minus sign (—) for the negative.

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We know now that positively and negatively charged bodies do not actually attract one another, but that they produce certain changes in the medium between them, and that they are drawn toward each other by the stress of this intervening medium.

Electrics and Non-Electrics.—It was early discovered that all objects do not become electrified when rubbed. Glass, wax, sulphur, shellac, guttapercha and other substances were found to be among those that did become electrified and they were accordingly termed electrics; iron, brass, copper and others did not become electrified and they were accordingly termed non-electrics. This idea has since been shown to be erroneous, for if iron, brass and other metals of the same kind are mounted on glass rods they can be electrified. The condition is due simply to the conductive or non-conductive properties of the metal. When a non-conductor is rubbed, electricity seems to adhere to the surface, but when a conductor is excited, the electricity passes through it, and if it be connected with the earth by a conductor, such as the experimenter holding it in his hand without being insulated, it passes readily to the earth, and is neutralized. This, however, is impossible when the conductor is mounted on a glass handle and the operator does not touch it. This makes clear the meaning of the terms conductors and insulators or non-conductors. Conductors are those substances which allow electricity to flow along them, while insulators or non-conductors do not permit that. The metals are all conductors with slight variations in their conducting

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properties, while glass, resin, wax, and so on are insulators.

Simultaneous and Equal Production of Both Electrical States.—Neither positive nor negative electricity is produced separately; the presence of one implies that an equal amount of the other has been produced. One state appears on the thing rubbed and the other on the rubber; for instance, if glass is rubbed with silk, positive electricity appears on the glass and negative on the silk, and if resin is rubbed with flannel, negative appears on the resin and positive on the flannel. The fact that the two are equal is proved by imparting the electricity of the thing rubbed, and that of the rubber, to some insulated metal, when it will be found that no electricity is present on the metal, for the equal charges have neutralized each other, thereby leaving the object in its normal state.

Electric Charges and Their Distribution.—The quantity of electricity produced is known as an electric charge and may be of varying value. If an electric charge be produced on a non-conductor by friction, it remains just where the friction took place, not becoming distributed over the object, or, if so, very slowly; but when a conductor is charged the electricity is immediately distributed over the entire surface, although not necessarily equally on all parts of it. A static charge of electricity always remains on the surface of the thing charged. It is easy to prove this in many ways; for example, the fact that it does not matter what the interior of the charged sphere is, or whether there is any interior or not, demonstrates that the surface takes the entire

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charge. This, however, refers only to static charges, for dynamic currents flowing in circuits always flow through the substance of the conductor.

The uniformity of distribution of an electric charge over the surface varies with the shape of, and the influence surrounding the charged body. A sphere which is properly insulated and protected will have a uniform distribution of the charge over its surface. If a charged conductor be brought near the sphere, and is of the same electrical state as the sphere,—as both being charged positively,—the charge on the sphere will repel the charge, or the greater part of it, to the opposite side of the conducting body, while, if the approaching body be charged with the opposite state, as positive and negative, the charge, or the greater part of it, on the conducting body will be drawn to the side nearest the sphere.

If an elongated spherical conductor with rounded ends be charged, the greatest density of the charge will be found at the ends where the curvature of the surface is greatest. If the ends differ in size (Fig. IV) the greatest density will be found on the smaller, and if one end of the charged body is run off to a small point, the density will be so great at this point that there will be a continual leakage of the charge in the form of a spray. It is for this reason that, in the static treatments, when we wish to give a continuous mild spray we use pointed electrodes; for the same reason we use large round balls in the construction of the machine, and, in fact, at all places, as the rounded corners of the stool and elsewhere, when we wish to prevent a leakage. On a

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flat, square surface the charge has its greatest density near the corners and edges, but is evenly distributed over the flattened surface.

If a conductor not charged be brought in contact with a charged conductor, the charge will be distributed between the two in proportion to the capacity of the conductors; that is, if they are of equal size and shape the charge will be equally di-

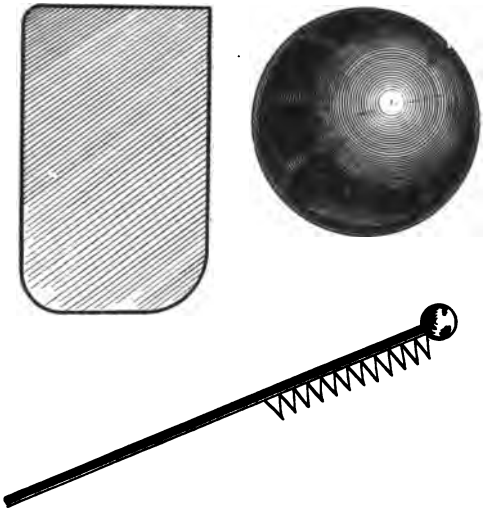

FIG. IV.

vided between them, but if of unequal size the larger one will take the larger charge. If a portion of a charge be removed from any part of a conductor, the remaining charge will distribute itself over the surface in the same proportion as before the original portion was removed, providing the same influence surrounding the charged body remains.

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Electroscope.—The instrument employed to detect the presence of a static charge is known as an electroscope (Fig. V). This is of no material use in medical electricity, but owing to the frequent references made to it in electrical works, a slight description of it will be given here. It consisted of two gold leaves suspended in a wide-mouthed bottle by a copper wire or other conducting material. We

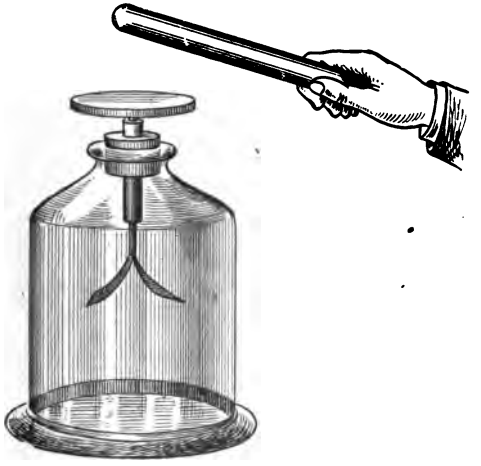

FIG. V.

have seen that when bodies are in the same electrical state they repel each other; therefore, when the upper part of the copper wire is charged with either a positive or negative charge the gold leaves are charged with the same and are accordingly repelled from each other. This instrument, which was formerly used for the detection of small charges, is now more used for the detection of ultra violet

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rays, and the rays emanating from radium. Its use for these purposes is based on the well-known fact that ultra violet rays and radium rays transform the atmosphere into a conducting medium, and when allowed to radiate between the insulated and grounded plates of an electroscope, the charges are at once dissipated.

Electrical Field.—If oppositely charged bodies are brought near each other the space between them

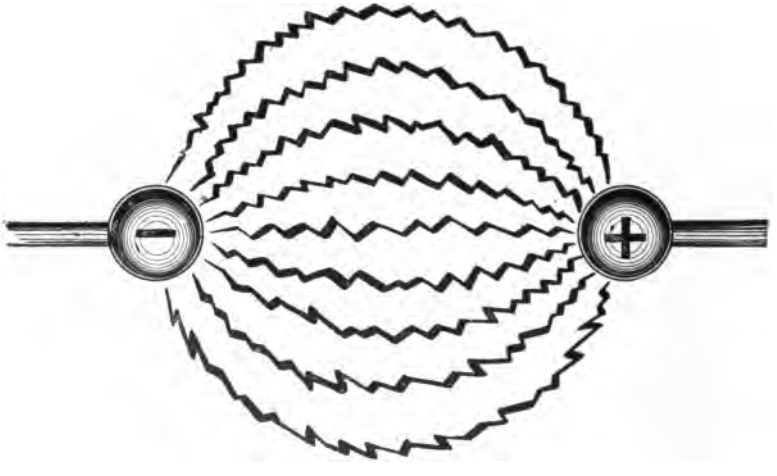

FIG. VI.

will be in a state of stress. The electricity on the bodies tends both to draw them together and also to draw the electricity on their surface together, which is the case when bodies are held stationary; in fact, it is claimed that the bodies are only drawn toward each other by the attraction exerted by the charges for one another, which is probably true,

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but as a charge cannot exist without having some body to rest on, the two propositions mean practically the same.

In Fig. VI are shown two balls oppositely charged, as is the case on a static machine, and the lines running from one to the other represent the lines of electric force from the one charged at a higher potential to the one charged to a lower potential, or, otherwise, from the positive to the negative pole. These lines can be distinctly seen between the two poles of a static machine. All the lines do not run absolutely parallel, but tend to separate from one another in the middle. It is supposed that midway between the poles there is a pressure exerted at right angles to the lines, tending to widen them. It is also believed by some that this variation is partially accounted for, at least, by the fact that the charge is not evenly distributed over the surfaces, being most dense at the points where the balls nearest approach each other. The space included in these lines is known as the electric field. In this field we place the patient for treatment, but we carry the field, by means of conductors, to some distance from the machine, as, for instance, to the insulated platform on which the patient sits.

Influence.—If a positively charged glass ball be brought near to, but not in contact with, an insulated conductor,—for example, a large brass ball mounted on a glass pedestal, as in Fig. VII,—the brass ball will exhibit all the characteristics of a charged body. If this brass ball is examined more closely, it will be discovered that an electric charge is on the surface nearest the glass ball, and also on

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the opposite surface, but that the middle exhibits no signs of electrification. If we now examine the glass ball, we find that it has lost none of its charge.

This power of a charged body to induce another charge in another body near it, but not in contact, is known as influence or electro-static induction. It was formerly termed induction, but that term is now used to indicate the induction of currents in

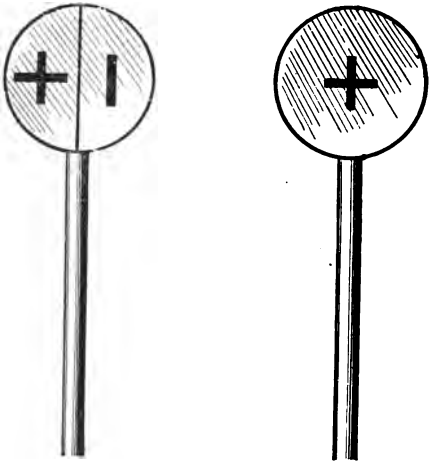

FIG. VII.

coils—as the induced or faradic current—and the term influence is applied to the induction of static charges.

A closer examination of the brass ball will reveal the two charged surfaces in different electrical states; the side nearest the charged glass ball will be negatively charged (opposite to that on the glass ball) and the opposite side positively charged. As

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soon as the glass ball is removed the electrical charge on the brass ball immediately disappears. This is explained on Franklin's theory that all bodies contain electricity, and that when a glass ball, containing a positive charge is brought near the insulated brass ball it drives the positive or plus electricity to the opposite side, leaving the near side negatively charged, and as soon as the charged glass ball is removed the two opposite electrical states rush together and neutralize each other. If a brass ball is not insulated, we find only the one kind of electricity, the negative, the positive being driven to the earth.

The quantity of the induced charge on the brass ball is in proportion to the amount of the charge on the glass—the greater the one the greater the other—and the nearness of their approach. A charged ball can never induce a greater charge than it possesses, that is, it can never produce a greater charge of negative electricity on its approaching side, and the same amount of positive on the opposite side. Bring the charged glass ball close enough to the brass ball and the stress of the medium becomes so great that it breaks down, a spark passing from the positively charged glass ball to the negatively charged surface of the brass ball, which is thereby neutralized, leaving the positive charge permanent on the brass ball, for when the influence of the charged ball is removed there is no negative electricity left to neutralize it as was the case before.

If we wish to leave the brass ball permanently charged with negative electricity, the operator may

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touch it with his hand or with a wire connected with the earth, in fact, with anything that is not insulated, while it is under the influence of the glass ball; when the positive charge will escape to the earth, leaving the negative charge which will be permanent. The question naturally arises: Why does not the negative charge escape? The answer to this brings us to the definition of bound and unbound charges. The glass ball is charged with positive electricity; this has induced a negative charge on the near side and a positive charge on the opposite side of the brass ball. Now, it matters not what part of the brass ball is touched by the hand, the positive charge will escape, as it is "free" or unbound, but the negative, being "bound" by its attraction for the positively charged glass ball, does not escape. If the brass ball is now removed to a distance away from the glass, so that the influence of the latter is lost upon it, the negative charge being no longer bound to one side diffuses itself over the entire surface.

In the opening paragraph we saw how a charged glass rod attracted objects until contact was made and then repelled them; we are now able to explain that phenomenon. When the rod approaches the swinging metal, the surface near it is negatively charged; consequently, an attraction is set up between the two opposite states; when, however, they come in contact the negative electricity of the metal is neutralized by joining with the positive charge of the glass rod, and we have two bodies that, charged with positive electricity, which repel each other.

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In order to charge the body by static induction or influence, it is necessary that a non-conducting medium be between the charged body and the body to be charged, and the better this insulator the greater the influence of the charge; if a sheet of glass be placed between the two, the influence of the charge will be greater on the body to be charged than if space alone is the only insulator.

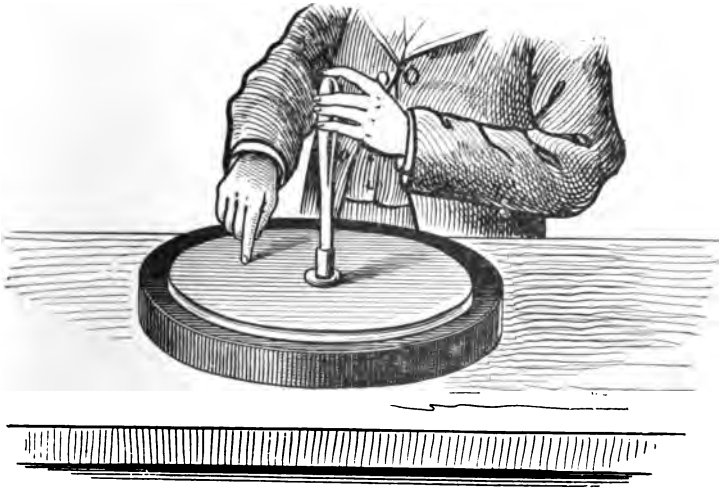

FIG. VIII.

Electrophorus.—(Fig. VIII). The electrophorus was the first instrument invented to produce a succession of charges from one original charge. It consists of two parts, one a cake of some resinous material or sulphur, which is the exciting body, and the other, a metal disk slightly smaller in diameter than the resinous cake; and mounted on a glass or

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hard rubber shaft so that it can be handled by the operator without danger of losing its charge. The resinous cake is beaten or rubbed with a woolen cloth or cat-skin, when it becomes negatively charged; the metal disk held by the glass or hard rubber handle is placed down over it. Now, the charged disk of resin acts by influence on the metal plate, charging it with positive electricity on the lower and with negative electricity on the upper surface. Touch with the finger, and the free negative charge escapes to the earth, leaving the positive charge on the lower surface, but this is diffused over the whole of the plate when that is raised by means of the glass or hard rubber handle. If the knuckle is now presented to the plate, a spark of positive electricity will pass to it. This experiment may be repeated several times without diminishing the original charge of the resinous cake.

Friction Machines.—There are two general classes of electric machines for producing static charges—the friction and the influence machine. For medical use the former has been entirely superseded by the latter, but a description of a simply constructed friction machine will not be amiss, so that the distinction between the two may be more easily understood. Influence is a very important feature even in the friction machine and nowhere is it more simply illustrated. Fig. IX is an illustration of one of the older and simpler forms of the friction machine. It consists of a glass cylinder so mounted on an axis that it can be turned by the hand. To the left is placed the rubber which is intended to produce the friction; this consists of a piece of wood mounted on

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a glass pedestal so as to be insulated. On the side nearest the cylinder this piece of wood is covered with a strip of leather, which has on its surface an amalgam of zinc and tin. To this is attached a piece of silk which covers the upper surface of the cylinder. At the right, mounted on a glass pedestal for insulation, is an oblong brass cylinder with rounded ends, at one end of which is a row of spikes known as collectors, and at the other the

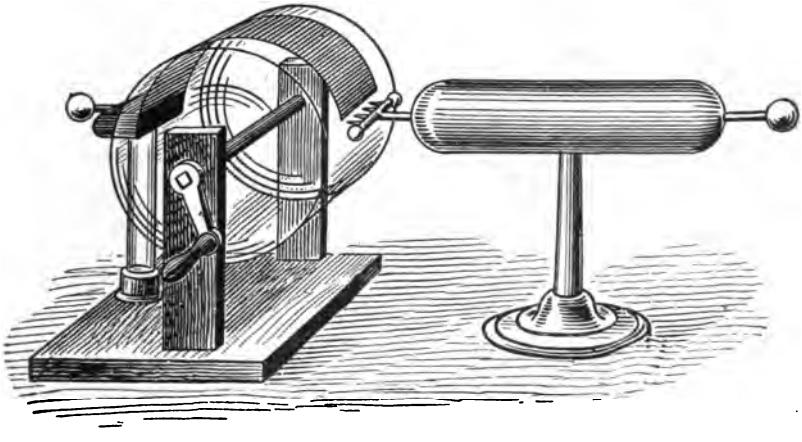

FIG. IX.

brass ball from which the sparks may be drawn. This is known as the prime conductor. As the cylinder is made to revolve, the friction of the amalgamated rubber produces electricity; the positive adheres to the glass cylinder and is carried over until it reaches the points where it acts inductively, producing a negative charge on the near end of the brass cylinder, and repelling the positive charge to

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the other end or the ball. The effect of the points is to emit an electric wind between the points and the glass cylinder, thereby leaving the prime conductor charged positively, and, at the same time, neutralizing the positive charge on the glass cylinder so that it returns to the rubber in a neutral state. The negative charge of the rubber, which is equal to the positive of the cylinder, may be collected in

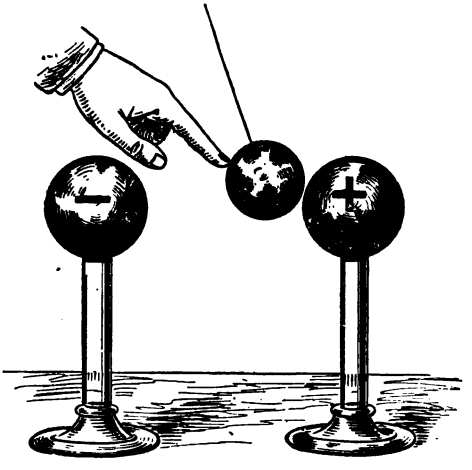

FIG. X.

a similar manner, or it may be conducted to the earth and neutralized. The plate machines, which are more commonly seen, act on precisely the same principle.

Influence Machines.—The development of the influence machine has revolutionized the use of static electricity in medicine. There are three forms on the market, the Toepler. the Wimshurst and the

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Holtz. Three principles govern the action of all these machines: First, there must be a slight initial charge; the Toepler and the Wimshurst are self-exciting, but the Holtz is not. Second, the principle of influence or static induction must be constantly borne in mind. Third, what has been termed "the principle of reciprocal accumulation," in other words, the electric charge which is induced from an initial charge without taking any of it, is stored up in another body, which, in turn, induces other charges which are stored up in the first, and so on, each making the other stronger without giving up any of its own charge.

In order to make this more easily understood, as it is the essential feature of these machines, let us glance at Fig. X, which shows two brass balls mounted on glass pedestals, and another ball suspended by means of a silk thread. Now, suppose the ball to the right receives a small positive charge; as the swinging ball comes near, the negative charge is induced on its approaching side and a positive charge is driven to the opposite side. If the swinging ball is now touched by the finger the positive charge passes to the earth, leaving the ball negatively charged, and when allowed to swing to the ball at the left, so as to touch, it charges that with negative electricity; in turn this induces another charge in the swinging ball, as it is leaving; then, if again touched, which at the same time makes it neutral, takes off the negative electricity and leaves the ball positively charged, it will, by coming in contact with the first ball, give to that its charge, while another charge is induced in the

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swinging ball as it is leaving, and so on, accumulating charges after charges. This is the principle on which all different types of influence machines are constructed.

Toepler Influence Machine.—The Toepler machine con-

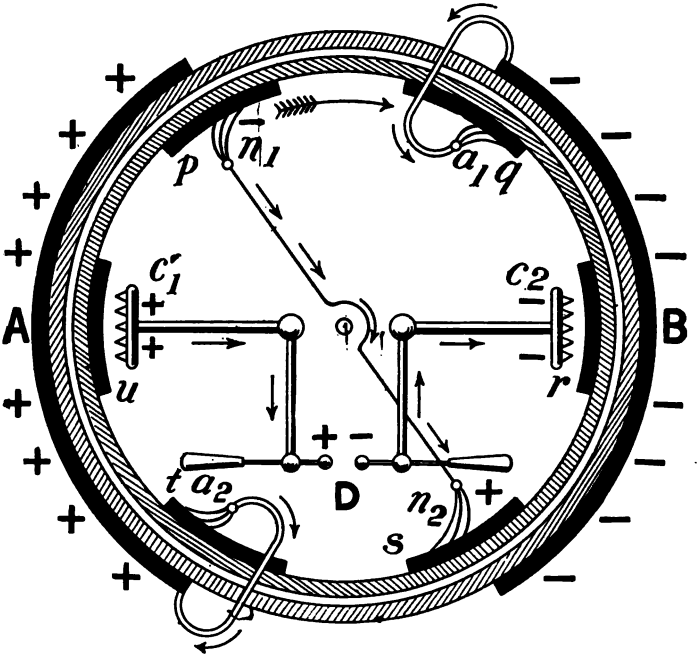

FIG. XI.

sists of a stationary glass plate which has, fastened to its outer side, two strips of metal, known as its field plates; these are its inducing plates. On a revolving glass plate, fastened to the side opposite the stationary plate, are smaller pieces of metal,

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known as the carriers; a pair of neutralizing brushes, a pair of appropriating brushes, and collectors or prime conductors, to collect and conduct the electricity generated to the poles of the battery.

Figure XI* represents the construction of a Toepler machine with two glass cylinders, which are used for convenience of illustration; the machines, however, are always made of glass plates. The outer glass cylinder is stationary and has the field plates, A and B_2 attached on either side. The inner cylinder revolves and has metal carriers, P, Q, R, S, T and U, attached on its inner surface. Running diagonally through the centre is a rod which has the neutralizing brushes N^1 and N^2 attached on either end. The appropriating brushes, A^1 and A^2, have metallic contact with the field plates. The collectors and prime conductors, C^1 and C^2, collect and conduct the electricity to the poles at D.

The operation of this machine is simple. Suppose there is a slight positive charge on field plate A. As the metal carrier passes along on the revolving inner plate it receives by influence a charge of negative electricity on the side nearest approaching the field plate, and a positive charge of equal quantity on the opposite side. As it passes the neutralizing brush N^1, the positive charge is conducted to S at N^2. As the inner plate continues to revolve P comes in contact with the appropriating brush at A^1, and, therefore, gives a negative charge to field plate B. As this carrier passes out from the

*Fig. XI is taken from Elementary Lessons in Electricity and Magnetism by Sylvanus Thompson.

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influence of field plate B it is touched by the neutralizing brush N^2, leaving it positively charged; this charge it carries to field plate A at A^2, and so each receives a reciprocal charge from the other. When the carriers are touched by the appropriating

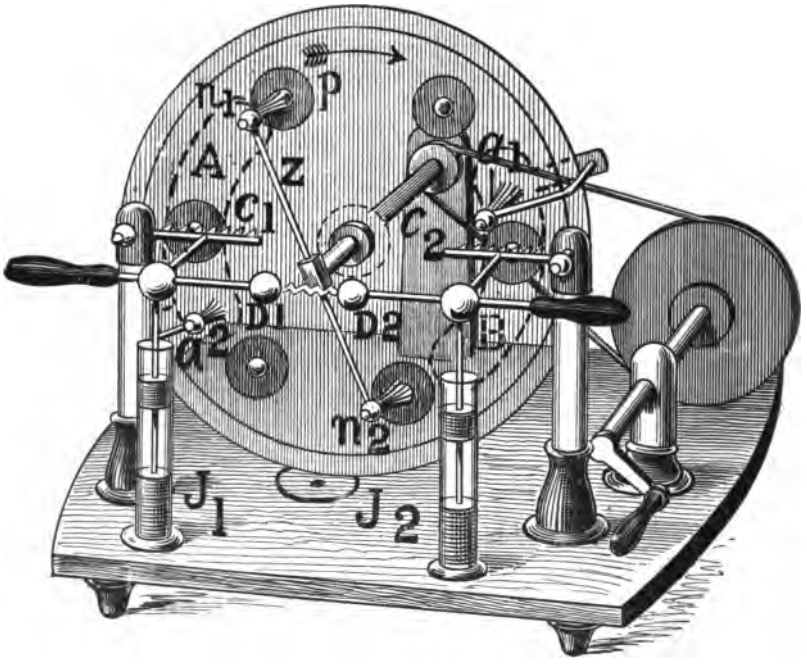

FIG. XII.

brushes, A^1 and A^2, they have, in proportion to their size, just as great a charge as the field plates. The carrier on the left, being positively charged as it approaches the collectors, induces two charges in the prime conductor, the positive being repelled

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out to the pole while the points allow an electrical wind to pass across from the metal carrier, thus neutralizing the positive charge on it. It is then charged again by influence. The field plate as well as the metal carrier acts by influence on the prime conductor. Precisely the same process is taking place on the right side, except that the charges are just the opposite.

Figure XII represents a Toepler machine as it is in use today. It operates on precisely the same principles as the one just described, the only difference being that plates are used instead of cylinders. The two field plates, which are made of paper and tinfoil, can be seen on the back of the stationary plate which is just behind the revolving plate, and is three inches larger in diameter. The metal carriers are distributed on the front of the revolving plate. They are round pieces of tinfoil with a metal button in the centre, and are securely cemented to the glass. The neutralizing brushes are attached to the bar, running diagonally across the front. The appropriating brushes have a metal connection with the field plates by a strip projecting down from them to meet the arm of the brushes as they pierce the stationary plate outside the diameter of the revolving plate. The collectors or prime conductors have adjustable poles which can be drawn apart or closed at will. As seen in front, the Leyden jars are fixed, with their outside coating connected underneath the platform.

This machine is self-exciting and will generate electric charges in all kinds of weather, only requiring a case to protect it from dust. It is simple in

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construction, needing but little care. Both the

FIG. XIII.—TOEPLER MACHINE.

neutralizing and the appropriating brushes should

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make good contact with the metal carriers, and the neutralizing brushes should be so placed as to touch the carriers while under the influence of the field plates.

Wimshurst Machine.—The Wimshurst machine has

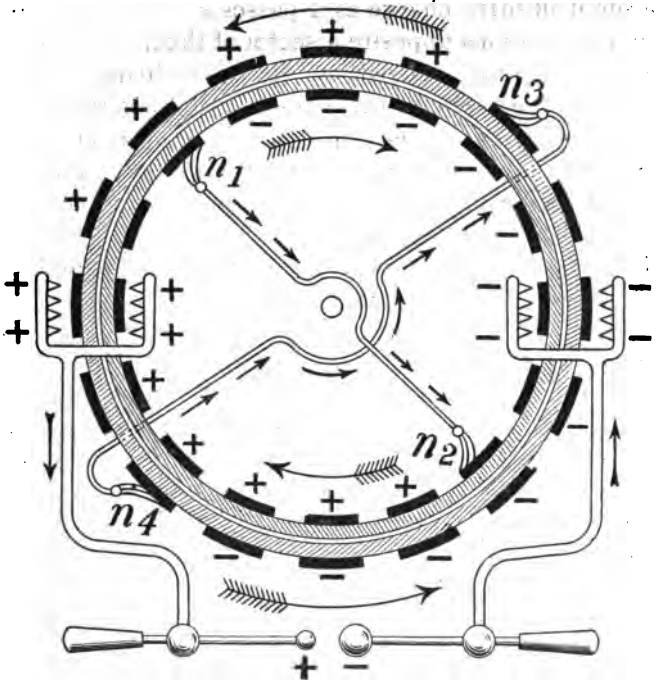

FIG. XIV.

no stationary plates and no field plates. It consists of two glass plates which revolve in close proximity and in opposite direction, having on their outer surfaces metal carriers which act at the same time as field or inducing plates.

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Figure XIV* represents a machine constructed from cylinders, one rotating inside, the other outside. The points of the arrows indicate the direction the cylinders are supposed to rotate. If one of the sectors at the top of the outer cylinder receives a slight positive charge as it passes along from right to left, it comes opposite a sector of the inner plate, which is being touched by the neutralizing brush N^1, and the positive or unbound charge is thereby conducted away, leaving the sector negatively charged. As this sector moves from left to right it comes opposite a sector on the outer plate, that is touched by neutralizing brush N^3, which neutralizes its negative or unbound charge, thereby leaving it positively charged. After a few turns all the sectors in this way become charged, those of the outer plate on the upper half carrying positive charge from right to left, and those of the inner plate carrying negative charge from left to right. Exactly the same thing is going on at the lower half, with the exception that the respective charges are carried by opposite plates, the inner one carrying the positive and the outer carrying the negative charge.

It will be seen, by a little study of the diagram, that the sectors of both outside and inside plates have the same charges as they pass the collectors or prime conductors. those on the left having positive and those on the right negative charges. These collectors or prime conductors act the same as in the Toepler machine. Two charges are induced in them,

*Fig. XIV is taken from Elementary Lessons in Electricity and Magnetism by Sylvanus Thompson.

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the bound running on or off the combs, according to its positive or negative character, and neutralizing the charges on the sectors so that when they emerge from the prime conductor they are in a neutral state, ready for another charge of opposite potential to that which they carried to the poles. Figure XV illustrates the Wimshurst machine as it is seen in the market. Let the front plate represent the inner

FIG. XV.

cylinder of Figure XIV and the back plate the outer, and we have precisely the same action as in the cylinder machine.

One defect in the Wimshurst machine makes it inferior to the Toepler and Holtz. If the sectors are placed near together, the spark it is capable of producing is very short; when the sectors are placed far apart, the sparks are proportionately longer, but

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they are also proportionately less frequent. It is, therefore, impossible to get as large a volume of sparks of the same length as with the other machines. The use to which the Wimshurst machine is put is to charge the Holtz when only small machines are needed, and can be placed under the case or inside of it. These small Wimshursts have been recommended as portable static batteries, but

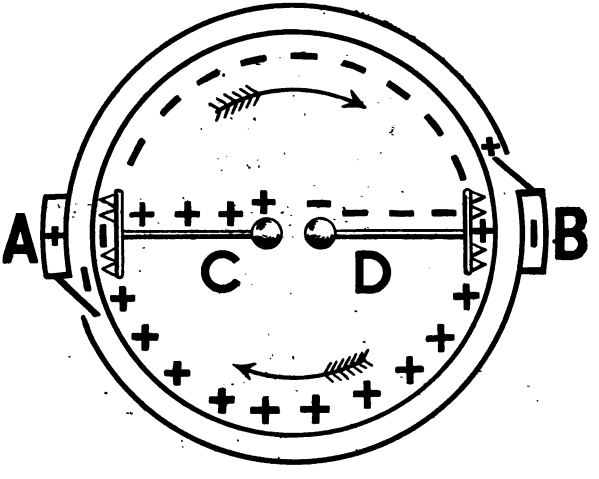

FIG. XVI.

as such they are of little use. If a Wimshurst machine is in order it will generate electricity in any weather. Care should be exercised in using the Wimshurst to see that the brushes make good contact, that the neutralizing brushes slope in different directions, and that the sectors come opposite each other when they are touched by the neutralizing brushes.

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Holtz Influence Machine.—The Holtz influence machine differs mostly from the other two by not having metal carriers on its rotating plates and no distinct neutralizing brushes, consequently it is not self-exciting. Figure XVI represents a Holtz machine made of cylinders. It consists of two cylinders, the outer one fixed, the inner one rotating in the direction of the arrows. The field plates on the outer side of the stationary cylinder marked *A* and *B* have pointed tongues which dip through the openings in the outer plate, coming in close proximity, but not in contact with the inner or revolving plate. The collectors or prime conductors, *C* and *D*, are seen in the center.

The working of this machine is easily understood, providing one has followed the laws of static induction or influence as they have been traced from the beginning. Suppose that field plate *A* has received a positive charge. It at once induces a charge on the prime conductor inside the revolving plate; the positive charge is repelled inward to the pole, and the negative attracted back to the revolving glass plate, and as the teeth of the combs are pointed a spray of electricity passes between them and the rotating plate, leaving its inner surface negatively charged. If this plate be now turned, this negative charge is carried over to the opposite side, where it induces a charge on the prime conductor of the opposite side. Here the negative charge is repelled inward to the pole, and positive charge is discharged from the points, neutralizing the negative electricity and at the same time recharging the surface of the plate positively, which, when carried around

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to the other side, augments the charge already established on that side. The pointed tongue of paper on the outside, connected with the field plate, always lets off electric winds when the front plate is revolved in the opposite direction to the point, which is opposite to that which is coming toward it

FIG. XVII.—HOLTZ MACHINE.

on the revolving plate and is simply the unbound charge constantly being induced in the field plate. For instance, if in Figure XVI a positive charge is carried under from right to left, the tongue at *A* will let off a negative charge, thereby leaving the field plate more positively charged, which in turn

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induces a strong charge on the prime conductor opposite. In this way charges are built up in the field plates, and enormous quantities are collected and thrown off at the poles. The Holtz machine is very sensitive to atmosphere changes; one should have it put in a case as nearly hermetically sealed as can be made. All static machines are more or less influenced by the weather, and should, therefore, if possible, be kept in a dry, sunny room.

The Toepler and the Holtz are the only practical working machines on the market; the experience of the writer has been confined entirely to the Holtz, which has given perfect satisfaction, but many physicians speak in the same way of the Toepler. A static machine should be selected which is capable of throwing voluminous sparks from seven to ten inches in length at least, in quick succession, across from pole to pole, when the outside of the Leyden jars are connected. The small machines with plates from fifteen to twenty inches in diameter are good for nothing, and the writer has never seen one too large for use.

For a static machine to work to its full capacity, there must be a certain amount of resistance in the external circuit. If the two poles are brought in contact, the machine works at its lowest capacity. When the poles are separated but an inch or two, the working capacity increases, and continues to increase the farther apart they are drawn, until the full capacity is reached. With a very soft X-ray tube, the resistance in the tube is slight; consequently, the machine works at a very low capacity, and the X-rays are correspondingly few and feeble.

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If now a spark gap is placed in the circuit, the resistance is increased, the machine works at a much greater capacity, and the X-rays are correspondingly increased.

Leyden Jars.—If a pane of glass be set up edgewise and a piece of tinfoil cemented on the middle of one surface of it, thus perfectly insulating it, the charge which it is capable of taking will be very small. Place now another piece of tinfoil on the opposite surface of the glass (Fig. XVIII) and the capacity

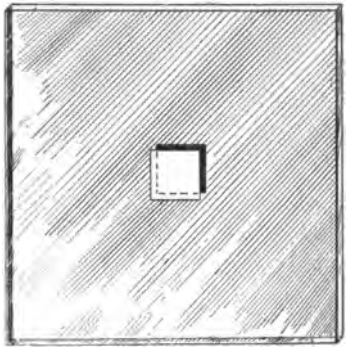

FIG. XVIII.

of the first for holding a charge will be somewhat greater. The reason for this is, that there is, by influence, a charge created on the second piece of tinfoil, which attracts the charge of the first to the side of the glass, leaving space for a heavier charge. Suppose a positive charge is given to the first piece of tinfoil, the charge next the glass in the second piece will be negative and that on the outer side positive. If we now connect the second piece of

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tinfoil with the earth by means of a wire, or the hand of the operator, and conduct off the positive charge, thereby leaving greater space for the negative it is possible to get a much greater charge on the first piece. By this means we are able to store up a very considerable charge. If several panes of glass, or one very thick piece, is used, the charge will not be as great as when one thin piece is used, for the attraction would be less. Poor glass, which is not as good an insulator as that of a good quality, since the impurities conduct more or less, does not retain so high a charge.

This is the principle of the Leyden jar. The inside of the jar is coated with tinfoil as well as the outside. The rod running from the machine is connected with the inside coating by a brass chain. It should be understood that the coatings of tinfoil do not contain the charge which in reality remains on the surface of the glass; if they are removed they contain scarcely any electricity, but on returning them to their position, the charge is the same as before they were removed.

If one Leyden jar is to be charged, it is necessary to connect the outside coating with the earth, so that the free, unbound electricity may escape to make room for the bound charge. When, however, two jars are to be charged, as on an electric machine, the two outside coatings are connected. As the positive pole leads into one there is a free or unbound positive charge on its outside, and as the negative leads into the other, there is a free or unbound negative charge on its outside. Connecting, by means of a rod, these two unbound charges,

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positive on the one and negative on the other, they rush together and, consequently, neutralize each other, the same as if both were connected with the earth. On the Holtz machine the connection of the outside coatings of the jars is made by laying a small brass rod across hooks provided for that purpose.

As the Leyden jars store up electric energy, positive on one side and negative on the other, it is plain that in order to discharge one, the outside and inside coatings must be connected by some conducting material, or at least brought close enough together that a spark may pass. The larger the jar, the greater the charge it will contain. The office of the Leyden jar, when attached to an influence machine, is to store up a quantity of electricity and let it off in large volumes. If a static machine is set in motion without the attachment of the Leyden jars, or even with them attached but their outside coatings not connected, a luminous spray will pass from one pole to the other so long as the two discharging poles are near together but do not touch. As these discharging poles are drawn apart the spray changes color, is not so luminous and is more interrupted. Now, connect the two outside coatings and large, powerful sparks will jump across. The Leyden jar simply collects the electricity until it can contain no more, when the two charges rush together. The rapidity of the discharge will depend on the greatness of the charge and the capacity of the machine.

When the jars are used during static treatment, and their outside coatings connected, they simply

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increase the size and volume of the spark. They are used also in what is known as static induced treatment, which is the alternating current, having, similar to the faradic current, a greater velocity in one direction, but, of course, differing from the faradic in character and discharge. While the jars are filling, the unbound charge, with but feeble voltage is passing through the patient connected with the jars; the jars become filled until they can contain no more, when suddenly a spark passes between the two poles of the machine; this spark suddenly empties the jars, the bound charges on the outside of the jars are as suddenly released and rush through the patient with enormous force and in just the opposite direction to the unbound charge. While these two are equal in amount, the electro-motive force of the bound charge is so much greater than the other that it predominates just the same as the make current with the Ruhmkorff coil. When the plates of the machine are made to revolve rapidly, the force of the charge is so great that the Leyden jars are filled and emptied many times per minute. These discharges are of an alternating high frequency character and will be considered in the chapter on high frequency currents.

To have a static machine give the best results requires constant care. As dust acts as a conductor of such high potential currents, the case and the prime conductors should be frequently and thoroughly wiped with a warm dry flannel. During warm, humid weather the case must be kept dry by placing inside of it dishes containing chloride of calcium and having it as nearly hermetically sealed as pos-

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sible. When the calcium becomes saturated with moisture it should be replaced.

In testing the polarity of a static machine the poles should be drawn a few inches apart, when a bright spark will appear at the cathode. This test is only reliable when the poles are separated but a few inches, four to six, and is not to be altogether depended on when they are drawn wide apart.

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CHAPTER II.

INDUCTION COIL.

If we wind a coil of wire as thread is wound on a spool, the wire being covered with silk so that one turn or convolution may not be in contact with another, and then wind another coil in the same manner, having it large enough to slide over the first coil, and attach the two ends of the first coil to the plates of a primary cell and the two ends of the second coil to a galvanometer, we find that when the second coil is rapidly placed over the first, the galvanometer needle is deflected, but it immediately returns to zero, where it remains until the second coil is suddenly removed, when the needle again is deflected, but in the opposite direction. This first coil is known as the primary coil and the second or outside coil as the secondary; the current produced in the secondary coil is known as the induced current. If this secondary coil is very slowly placed over the primary there will be but little, if any, deflection of the galvanometer needle, and the same is true if it be very slowly withdrawn. If, after the secondary coil has been placed completely over the primary and allowed to remain there until the needle comes back to zero, the primary circuit be suddenly broken by disconnecting one of the wires that connect the cell with the primary coil, the needle will deflect much farther than when the secondary coil is suddenly withdrawn from the

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primary, for the breaking of a metallic contact is more sudden than the change produced by moving one coil over the other.

It is, therefore, evident that the current in the secondary coil owes its existence to variation in force in the primary circuit, and also that the more sudden this variation, the greater is the secondary or induced current. If we have a galvanometer in the primary circuit as well as the one in the secondary or induced circuit, we will find that when the primary circuit is made by connecting the wires of the cell with the primary coil, the two galvanometers will register currents traversing in opposite directions; when these currents are broken, the needle in the primary circuit will return to zero, while the one in the secondary will swing in the same direction as the one registering the primary current when the circuit is closed. This is due to the fact that an induced current always travels in a direction opposite to the inducing current. When the current suddenly rises in the primary circuit or coil, the induced current is in the opposite direction; when the primary current is broken the induced current suddenly recedes; the current in the secondary or induced circuit suddenly reverses, travelling in the opposite direction, or in the same direction as that of the rising primary current.

We may further intensify the deflection of the galvanometer needle of the secondary circuit, by placing inside the hollow primary coil an iron bar or a bundle of small iron wires known as a core, completely filling the opening. The action of the iron core is first to concentrate the lines of force set

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up in the coil of wires, as a lens concentrates rays of light. Currents are also set in action or induced in the iron core itself, which being rapidly demagnetized by the breaking of the connections with the battery, greatly increases the strength of the induced or extra current momentarily set up in the coils.

While, as has been seen, the induced current is a to-and-fro current travelling in both directions, we are accustomed to speak of it as travelling in one direction or the direction of the opening current, which is also the direction of the primary current. This statement, however, needs a certain amount of qualification. The quantity of the discharge given off in each direction must be equal, the only difference being in the voltage, owing to the rate of discharge. This is due to the fact that the variation stage to which the opening current owes its existence is more sudden than the closing current. If there were no external resistance, each discharge would have equal electrolytic effect; but as the external resistance increases, the one with the least voltage lessens in its effect more rapidly than the one with the greater voltage. When the resistance reaches a point where the one of lower voltage or the one produced by the make of the primary circuit is incapable of overcoming it, we obtain the action only of the one having the greatest voltage.

Fig. XIX illustrates these points. The long drawn out curve above the line represents the discharge of low voltage or the impulse from the make current, while the short but sharp curve below the line indicates the rapid but short impulse of the discharge of the break current, the space between this and

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the next make representing the period of rest. It will be seen by this diagram that the induced current is made up of impulses which run in cycles and is not therefore rhythmical. In using the induced current through great resistances, such as a Crookes' tube, the current of low voltage is unable to overcome the resistance of the vacuum, and as a result you get the effect of the current of high voltage. In very low vacuum tubes the resistance is also very low, and here we may get the passage of the make current through the tube, which being of the oppo-

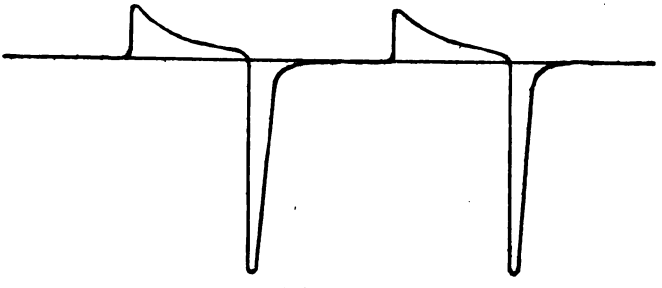

FIG. XIX.

site direction makes a blur. To overcome this, a spark-gap is placed in the circuit which increases the resistance and cuts out the make current, leaving only the break current.

For inducing large charges for X-ray and high frequency work it is necessary to have a coil well constructed. Both primary and secondary coils should be carefully wound and the insulation of the wire perfect. The insulation should also be very perfect between the two coils, as well as in the terminals. If this is not done, and the insulation

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breaks down, the coil is ruined. The best advice that can be given in regard to selecting a coil is to buy it of a good reliable maker.

In purchasing a coil one should be selected that gives off a twelve inch spark. One larger than this is certainly not necessary for therapeutic work, although for skiagraphic work a longer spark may be needed. One should also be selected that has two windings of the primary coil, one in series and one in parallel, for it will be found that according

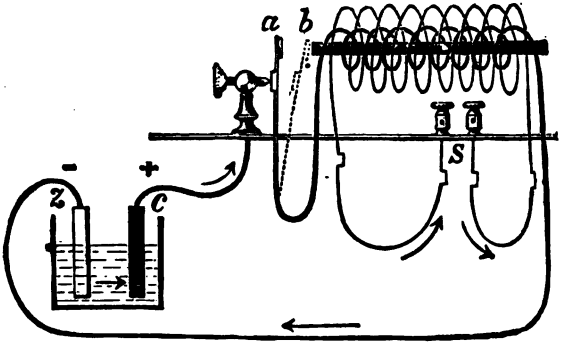

FIG. XX.

to different conditions one will give better results than the other.

Interrupters.—Originally the interruptions in the primary circuit were made by means of an automatic interrupter known as the vibrator or rheotome. The connection of the primary coil with the cell is by way of the post at the left in Fig. XX, thence to flexible spring *a*, and from the spring to one end of the primary wire, the remaining end of which is attached to the other element or plate in the primary

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cell. If the cell is in working order, a current traverses the primary wire in the course just mentioned, and, as it rotates around the iron core, that becomes strongly magnetized. The spring, having a piece of iron affixed to its free extremity, is attracted toward the end of the iron core of the primary coil at *b*, until it breaks its connections with the end of the screw, thus breaking the circuit and the current ceases to flow from the cell. At the same instant the magnetism in the core ceases, and the spring, by its own resistance, returns to its original position in contact with the point of the screw, when the circuit being again made, the spring is again attracted, the circuit is again broken and the spring flies back again, and so on. This is repeated very rapidly, and the rapid making and breaking causes the extra current to give those shocks that in rapid succession constitute the induced current. The windings of the fine wire in this cut represent the secondary coil.

While the rheotome works admirably on small induction coils, such as are used for the administration of currents to the human body, and are known as faradic coils, they have many disadvantages when larger coils are used. In the first place the vibrations are slow. The great cause of defect when used on coils of large potentiality is that an arc is formed at the point of break, which lessens the sharpness of the variation of current in the primary circuit, and, consequently, lessens the potentiality of the discharge from the secondary coil. Various interrupters of this kind have been made by different manufacturers. Some have two points of contact

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instead of one. Others have a separate circuit for the break, so that the variation of strength in the primary coil will not affect it. When storage batteries are used for producing the primary circuit, these vibrating interrupters will do very well for both X-ray and high frequency work, but at best they are far from satisfactory on a 110 volt circuit.

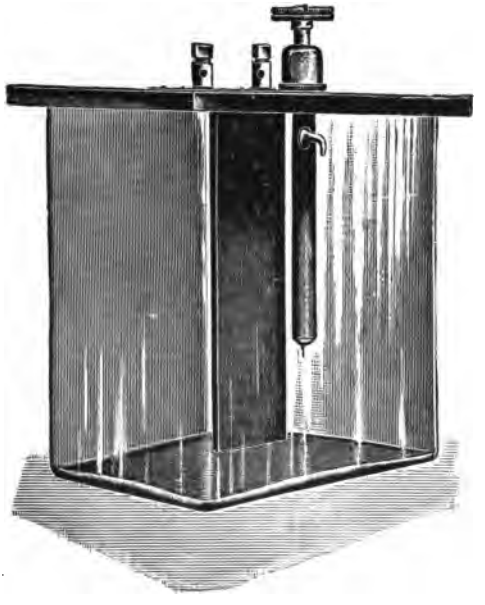

FIG. XXI.—WEHNELT INTERRUPTER.

There are today many interrupters on the market, each perhaps having some special point of advantage. All, however, come into two general classes, the electrolytic and the mechanical.

The Wehnelt interrupter consists of two elec-

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trodes, one very large and made of lead, and the other very small, generally a small platinum wire with its point projecting from a porcelain tube, immersed in a vessel containing some electrolyte, preferably a dilute sulphuric acid solution. The amperage passing though the primary coil depends upon the amount of wire exposed in the acid. On the other hand, the less the amount of platinum exposed the more rapid are the interruptions. In most makes this is so arranged that the platinum point projecting from the porcelain tube, can be lowered or raised at will, and by this means the amperage can be regulated in these certain lines.

The platinum electrode should be attached to the positive pole, and on this account the Wehnelt may be used for interrupting an alternating current, for it only interrupts as the positive pole is attached to the platinum; therefore, as the current is alternating and it becomes negative, practically no interruption takes place. Two theories are at present in vogue regarding the action of this strange little instrument. One is that by the process of electrolysis, bubbles of gas collect in large numbers around the platinum point and explode, thus throwing the liquid away from the contact and breaking the circuit, when the rushing back of the fluid makes another contact and another explosion takes place, and so on. Another theory is that insulating gases collect over the platinum point, thus breaking the circuit. The rapid interruptions and electrolytic process cause the fluid to become greatly heated, when the interruptions will be unsteady. This fault may be overcome by having

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two separate jars, so as to switch from one to the other, or, perhaps, better still, by having a very large vessel containing so much fluid, and offering such a large surface for the dissipation of heat, that it may be run hours without overheating. Whatever may be the *modus operandi* of the working of this instrument, it certainly possesses great merit, and has made the coil far more effective in X-ray work than it was before its invention.

The Caldwell interrupter is another form of electrolytic break. It is constructed of a jar partially filled with dilute sulphuric acid, in which is immersed another jar made of some insulating material perforated with one small opening. The working of this interrupter is best described by the inventor.

"When the primary current of an induction coil is passed through this apparatus there is comparatively little heating of the liquid except in the aperture connecting the two chambers, where the current density is very large on account of the small area of the aperture. At this point, therefore, sufficient heat is developed to vaporize the liquid rapidly, and bubbles of steam which form, break the connection between the liquid in the inner jar and that in the outer jar. As soon as the current is broken the heating stops and the two portions of the liquid come together again, completing the circuit. The frequency of the interruptions will depend upon the strength of the current, the size of the aperture, the resistance of the electrolyte, and to some extent upon the inductance of the circuit.

"This apparatus is not so susceptible to changes

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in the strength of the exciting current, or to changes in the temperature of the liquid, as the Wehnelt. It will, therefore, remain in operation somewhat longer, and admits of a wider range of adjustment of the exciting current. The action of this interrupter is quite independent of the direction of the current through it, therefore, when employed for operating induction coils on the alternating current circuit the current will be broken at each alternation, and the secondary discharges will alternate in direction. Such discharges are not suitable for operating single-focus tubes, and the interrupter is, therefore, not adapted so well for alternating currents as the Wehnelt interrupter. With the alternating current it is possible to use double-focus tubes, but these are usually unsatisfactory except for therapeutic purposes." These electrolytic interrupters will give excellent results for X-ray work, but they are not so well suited for high frequency work.

Mechanical interrupters have been constructed of every conceivable form. Some are made of many segments placed in a stationary circle, while a spindle with a corresponding number of segments is made to revolve inside. According to the number of segments the current is interrupted, 2, 4, 6, 8 times with each rotation of the spindle. This spindle is run by a small motor, and the speed may be varied at will by means of a rheostat. With the best constructed interrupters of this kind arcs will be formed, even with condensers in the circuit, and the segments will wear away rapidly. The McKenzie–Davidson is one of the simplest mechanical

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interrupters, and one that does not readily get out of order. A shaft attached at one end to a small electric motor is set at such an angle that a knife blade attached to the distant end dips into the mercury at each revolution, the current being made by the contact of the knife blade with the mercury. Interruptions of the current are not more than about two thousand per minute. Two knife blades may be placed on the shaft, making the interruptions

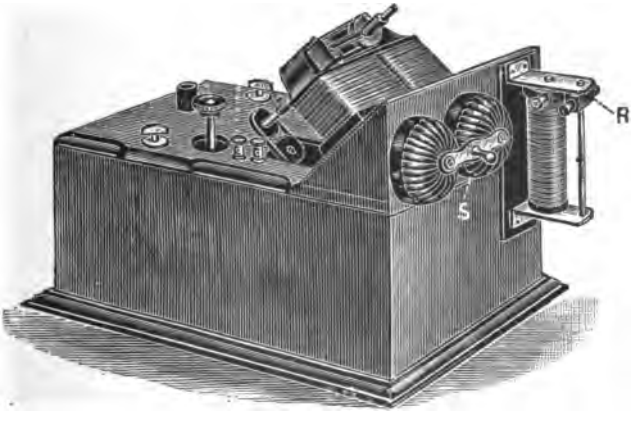

FIG. XXII.—McKENZIE-DAVIDSON INTERRUPTER.

double in number, but even with this the interruptions are comparatively very slow. The McKenzie–Davidson interrupter is best suited to high frequency currents.

The mercury jet interrupter, although it is a mechanical interrupter, has principles which distinguish it from other interrupters of that class. There is a perpendicular shaft attached at the upper end to a high speed motor, its lower end being immersed in

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mercury. The lower half of this shaft is hollow, and is made in the form of an auger, so that when it revolves at a high rate of speed the mercury is raised up to a small reservoir about midway of the shaft; this reservoir has projecting from it two hol-

FIG. XXIII.—MERCURY JET INTERRUPTER.

low iron tubes, through which the mercury is projected with such force that it is made to come in contact with sectors arranged in a circle in opposite pairs. The circuit is made by the contact of the mercury with these sectors and the break when the

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mercury jet goes between them; the greater the number of sectors the greater the number of breaks per minute. The interruptions of the current with this instrument are slow as compared with the electrolytic interrupters, but it is possible to get from seven to ten thousand per minute. It is a very useful interrupter both for X-ray and high frequency work.

Condensers.—When any interrupter except the electrolytic is employed, a condenser must be used in the primary circuit to prevent an arc at the point of interruption. Even large condensers do not entirely prevent this, but they assist very materially. These condensers are made of metal foil and an insulating material, usually tinfoil and glass. The alternate layers of the foil are connected, making two conductors of large capacity, and when these two surfaces are connected to the points of contact between which the current is broken, the discharge, which would otherwise cause an arc between these points and thus prevent the sharpness of the break, discharges into this condenser.

Rheostat.—A rheostat by which the volume of current passing into the primary coil can be regulated should always be placed in the primary circuit, provided the street main is used for energizing the coil. It is not necessary when storage batteries are used.

Ammeter.—For very accurate work both in X-ray and high frequency, an ammeter should be placed in the primary circuit. The amount of current passing into the coil bears a correct relation to the amount of energy put out of the secondary coil. There are, however, many other factors entering

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into the relationship, especially in X-ray, such as the frequency of interruption, the windings of the coil, the height of vacuum, and so on. Some of these, also, enter into the production of high frequency currents.

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CHAPTER III.

THE X-RAY.

The discovery of the X-ray by Conrad Roentgen, late in the year 1895, was one of the crowning events of scientific achievement in the nineteenth century. Roentgen's discovery was only an advance from Hertz and Lenard, who had discovered that when a charge of electricity of a very high potential was put through a very high vacuum, it would radiate into the open air space around the vacuum tube certain rays which would affect a photographic plate, and that it mattered not whether this plate was exposed directly in a dark room, or whether it was encased in a pasteboard box. Roentgen, reasoning from this, thought that as these rays penetrate a pasteboard box, they might possible penetrate other opaque substances; he tried the human hand, and found that the rays penetrated the soft parts as freely almost as they did the box. Roentgen, however, deserves more credit than the above statement apparently gives him, for he discovered the existence of a new ray. Lenerd believed that the phenomena he found was only the extension of the cathode ray from the inside of the tube outward, and it was these rays which penetrated the box and affected the photographic plate. We are, therefore, indebted to Roentgen for the discovery of the new ray.

For the purpose of study of the physical proper-

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ties of the X-ray, we may divide the subject into the tube and the cathode ray; the nature of the X-ray; the electric energy necessary to excite the tube; the fluoroscope.

The X-ray Tube and the Cathode Stream.—If a vibrating bell be placed within a glass globe, from which the air has not been exhausted, the sound is conducted from the bell to the ear of a person standing within its range, since the air which is the conductor of sound, conducts the vibrations to the wall of the vessel, which, in turn, transmits them to the external air, and so on into space. If now the air be exhausted with an air pump, and the globe hermetically sealed, we find that no sound is heard, as the conducting medium has been removed by the production of a vacuum. If a platinum wire be placed within the vacuum and brought to a white heat, by the passage of an electric current through it, and a thermometer be so arranged that the rays of heat are focused upon it, we find, by the rise of the column of mercury, that the vacuum space conducts heat. The fact that an incandescent fibre within a vacuum bulb gives out a brilliant glow is sufficient proof that the vacuum space conducts light also. It is evident, therefore, that while air conducts sound vibrations it does not conduct light or heat.

We need not use an acquired vacuum to demonstrate that the conductivity of heat or light does not depend upon air as a conducting medium, for they both travel from the sun to the earth through millions of miles of space not filled with air, or, so far as we know, with any matter whatever. This conducting medium of light and heat is what we

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know as ether — sometimes called luminiferous ether, because it transmits vibrations of light; it is also known as universal ether, as it is supposed to exist everywhere, even between the atoms and molecules of solids.

If an incandescent lamp, which, as is well known, has a vacuum, is brought near the prime conductor of a static machine, the fibre within the lamp will be deflected; or, if a lamp which has a continuous current passing through its filament be brought near a magnet, the fibre will again be deflected. The ether, therefore, conducts the influence of electricity and magnetism as well as light and heat. Here, again, we have a greater example in nature. If we watch the daily variations of the magnetic needle for a period of ten and one-half years, we find that these changes are coincident with changes of the spots upon the sun, showing that there is direct transmission of magnetic influence from the sun to the earth.

We find that not only does a vacuum conduct electrical impressions, but the passage of currents of certain great intensities through a vacuum-blub produces certain radiations of energy, heat and light. These radiations are known as the anodal and cathodal rays. If we pass an electrical current through a tube which has but a comparatively low vacuum, we plainly see the radiations of certain molecules of the gas remaining within the tube, but as the vacuum is heightened by the withdrawal of more and more of the molecular material within it, the radiant gaseous molecules disappear, and are replaced by certain streams of energy which

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fluoresce upon the walls of the tube in a beautiful greenish color.

If we place within the vacuum-tube a light vane, delicately adjusted so that the cathode rays strike the paddles, the rapid movement of the vane indicates that there are radiations emanating from the cathode and passing with tremendous velocity in a straight line through the tube, no matter from what point the anode may enter. What all this radiant matter is, has not been fully determined, but it is believed to be composed of particles of matter belonging to the residuum of the vacuum and derived from electrodes, for when a vacuum is produced to the enormous pressure of one millionth of an atmosphere, there still remains within it thousands, yes, millions of molecules. This radiant matter within the tube was carefully studied by Sir William Crookes, who, in a lecture before the British Association, August 22, 1879, claimed to have discovered a fourth state of matter, thus dividing all matter into solids, liquids, gases and radiant matter. He claimed that this fourth state, or radiant matter, was observable only in a very high vacua. Recently Prof. J. J. Thompson, of Cambridge, England, has by a clever device been able, as he claims, to measure, or weigh, as it were, this cathode stream. He claims that it is composed of particles one thousand times more minute than the atom of hydrogen. The passage of an electric current through this vacuum-tube, in producing the cathodal rays, destroys the residual matter, whatever the nature of that may be, until the vacuum becomes so high that it is impossible to obtain any fluorescence, even with the greatest current intensity.

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Just what becomes of these residual molecules is not known. Many believe they are absorbed by the electrodes, while others believe that they are actually forced through the glass by the tremendous energy within. Whatever the cause, the heightening of the vacuum seems to be coincident with a long-continued use of the tube. If a new tube be put under great stress by the passage of a current of enormous intensity, and kept there steadily for any extended period of time, it will get very hot; the vacuum will run down rapidly, and, if the tube is a small one, the vacuum will become so low that the tube will be useless in an hour's time.

The ordinary tube used for both radiography and radiotheraphy today, has, within the bulb, two terminals, called, respectively, the cathode and anode, or anticathode. The cathode is made of aluminum, and is constructed so that the cathode rays emanating from it are concentrated or carried to a convenient point. The anode or anticathode is made of platinum. The reason for this is, that, in the first place, it does not allow the cathode rays which impinge upon it to pass through it, but reflects them back to the wall of the tube. It also has power to withstand a high degree of heat without melting. This terminal is set at an angle of thirty-two degrees, so that the reflection of the cathode rays bombard a certain area on the side of the bulb from which the X-rays emanate.

The focusing of the cathode rays on the anticathode is all important. If the tube is to be used for diagnostic work, the focus should be down to a small point, as the smaller the point of focus the

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sharper is the outline. On the other hand, the smaller the point of focus the greater the danger of puncture of the anticathode. For therapeutic purposes this is not necessary, as we do not care about the sharp outline, and as there is not so much danger of destroying the anticathode, the broad focus is preferable.

Most of the German makes of tubes have two anodal terminals, as in Fig. XXIV. This gives a little better variation of the tube than when there are but two terminals. When the positive pole is attached to the third terminal the tube will be softer, and the rays will have less penetrating power than when it

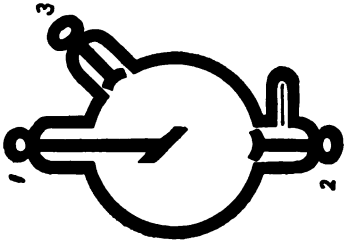

FIG. XXIV.

is attached to the anticathode. When the positive terminals are connected by a wire outside we get a condition between the other two, both as to penetrability and quality of X-ray. This is the best connection of a tube for radiotherapeutic work.

For therapeutic uses special forms of tubes have been constructed for the application of the rays to different parts of the body, or rather cavities of the body, such as the rectum, vagina, throat, etc. Some operators administer the X-ray to the cervix

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and uterus through a speculum. As the X-ray is not deflectible, it is necessary that the tube be placed just right, or no rays will go through the speculum. The tubes which come with the Friedlander shield, described further on, answers this purpose very well.

Crossar made a tube, Fig. XXV, which has a projecting ampula. The entire tube, excepting the end of the ampula, is lead glass and does not either con-

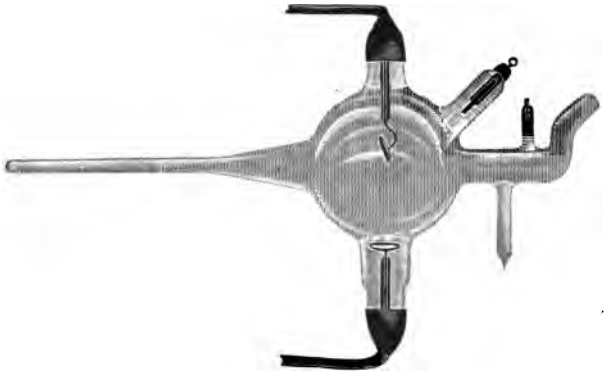

FIG. XXV.

duct or give off X-rays to a great extent. All that part of the tube is therefore practically a shield to the tissues, while the end of the ampula admits them freely. This is an excellent tube for use on the cervix, or certain parts of the buccal cavity.

Caldwell has devised a tube, by which the anticathode is placed in the end of the ampula, and from which X-rays radiate. The anode comes into the side of a tube that is similar to the old

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pear-shaped tube. If this anode is grounded the projection containing it may be used as a handle, and no shock is felt by the patient or operator. This is an excellent tube for admitting X-rays to the throat, rectum or vagina, in getting the rays direct to the parts that are diseased, although the X-rays given off are inferior to those emanating from an ordinary focus tube. They are, however, fully equal, if not superior, to those given off by the Crossar tube.

The X-ray tubes of commerce are very unstable articles. They may be made for a certain length of spark, and yet be found to work fully as well on a coil or a static machine of much less capacity. Tubes are also made for use on the static machine and for a coil. A tube made for the static machine has a very light anode or anticathode, and will not withstand the heavy bombardment from the heavier current of a coil. They will become so hot under this bombardment that a hole will be melted through them, and they are no longer of use. A tube that is made for a static machine cannot, therefore, be used on a coil. The tubes made for a coil have a much heavier anticathode to withstand this bombardment. Of course, they can be used with safety on a static machine, but this is not advisable, for the changing from a coil to a static machine always impairs the efficacy of the tube.

For use on any large coils, and when there is a large amperage of current passing through the primary coil, the anticathode should be water-cooled. With this tube the strongest current may be used to energize the tube without fear of melting the anticathode.

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If the vacuum is too low no X-rays are given off. As it rises, it reaches a point of greater efficiency, and, as it progresses beyond this point, its efficiency gradually lessens. These different states of the vacuum have been designated by the term soft, when the vacuum is low, hard, when the vacuum is high, and medium, when it is neither high nor low.

In therapeutics the height of the vacuum is very important, as largely by the variation of it, the special quality of ray desired is selected. How

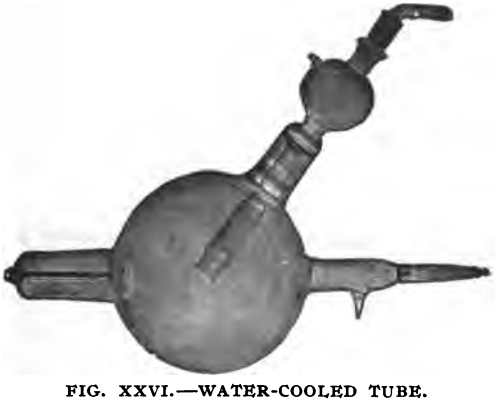

FIG. XXVI.—WATER-COOLED TUBE.

these different quantities of rays are to be selected is explained in another chapter. It is evident then that we must have tubes capable of a certain variation in the vacuum. For this purpose tubes have been constructed with a device for varying the vacuum, and these are known as regulating tubes.

Regulating Tubes.—Nearly all makers of tubes now have some arrangement whereby, without reopening the tube, the vacuum may be lowered, when it

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is in danger of becoming so high as to be useless. This is generally in the form of a third offshoot containing certain salts, and when a current is passed through it, gases are set free which lower the vacuum.

These regulating tubes are a necessity when they are used much, as in X-ray therapeutics. Every maker has his special design, and his own preparation which he places inside the tube for the lowering of the vacuum. Nearly all, however, are based on one principle; the increasing resistance of the tube as the vacuum heightens. The bypath or conductor which carries the electric energy through the mixture that sets free the gas necessary to lower the tube is set at such a distance from the terminal, that, when the resistance within rises to a certain point, it becomes greater than it is between the external terminal and the bypath conductor, and a spark passes through the mixture, setting free gas and lowering the vacuum until the resistance is reduced to a point lower than it is in the bypath circuit, when the fluorescence continues as before. A glance at Fig. XXVII will serve to make this clear. The chamber 3 contains the mixture through which, if a spark passes, gas will be generated, and the vacuum, as well as the resistance of the tube, will be lowered. This chamber is connected by a bypath 4, which can be set at varying distances from the external terminal 2. Now, as the vacuum rises within the tube, the resistance also rises until it becomes greater than it is between 2 and 4, when a spark passes through the chamber 3, setting free the gas and lowering the vacuum. It is possible

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with many makes, to keep the tubes at a low or high vacuum as we desire, by the distance we set 2 from 4.

Some makers construct tubes in which the vacuum may be raised by forcing a current through a substance which causes it to absorb some of the remaining atoms, but this is hardly necessary in a well constructed tube. Heating a tube with an alcohol lamp will temporarily lower the vacuum. This is due to the setting free of particles of the residual matter which adheres to the walls of the tube.

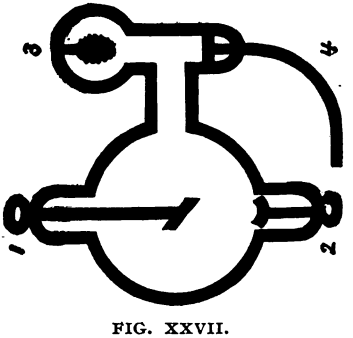

FIG. XXVII.

Another form of this type of tube is known as the osmosis tube. Palladium, when cold, is impervious, but when heated will allow a little air to perculate through it. A closed tube of palladium, with a projecting end, is sealed within the tube, and when the vacuum becomes too high, the projecting end is heated to a dull red heat. This makes the palladium tube slightly porous and allows a little air to enter the vacuum tube.

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Fluorescence.—As particles of matter within the tube are projected with great force against the opposite wall of the bulb, a tremendous friction, and more or less rebounding, takes place. Again, those particles charged with electricity in turn communicate a charge to the walls of the bulb. As bodies similarly charged have a repelling effect upon one another, those particles that have already been deposited exert a repelling influence upon those coming toward them, thus setting up an electric stress. All these conditions undoubtedly exert more or less

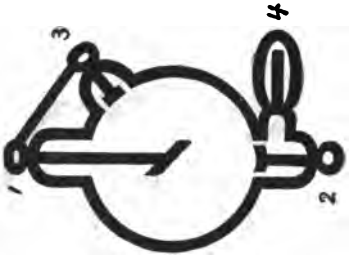

FIG. XXVIII.—TUBE WITH PALLADIUM TUBE INCLOSED IN GLASS COVER AT 4.

influence in producing fluorescence. This fluorescent stream of energy is subject to magnetic influence, and the power of the magnet on it, or its power to withstand the influence of the magnet, is in direct proportion to the height of the vacuum; if Crookes' tube has a projecting bulb containing potash, which, when heated, has the effect of slightly injuring the vacuum, the stream of energy will produce a sharper curve under the influence of the magnet, falling short of where it fell before the heat was applied to the bulb containing the potash.

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The Nature of the Ray.—The first question that arises is; What are these rays? Are they the cathodal rays extending through the walls of the tube into space? Professor Hertz, of Bonn University, Germany, succeeded in penetrating with the cathode rays gold leaf which was placed inside the tube, and was sufficiently thick to be opaque to sunlight. His student, Mr. Lenard, later succeeded in passing these rays through a thin plate of aluminum, — placed as a window in the bulb, — out into space, where they produce a fluorescence. These were positively cathode rays, as they were deflected by a magnet and exhibited all the characteristics of cathode rays.

The X-rays are not deflected by a magnet, as are the cathode rays, which are also absorbed by light to a much greater extent than are the X-rays. Regarding this point, the reflection and refraction of the X-rays, there was for a time some dispute among scientists, but the most conclusive proof of the accuracy of Prof. Roentgen's conclusions has been furnished by experiments. As has been stated in another part of this section, when sunlight is passed through the spectrum it is divided into several shades; that known as the ultra-violet, consists of rays which produce actinic effect upon a photographic plate. It has been suggested that, as X-rays produce this same actinic effect, they are identical with ultra-violet rays, which are also invisible to the naked eye as are the X-rays, and that the energy emanating from the tube assists them in penetrating opaque substances. If this were true, the photographic plates would respond

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to one as to the other. This, however, is not the case. Professor Stein, of Chicago, found that a slow plate responded just as quickly to the Roentgen rays as a very rapid one, and Mr. Edison discovered that a landscape plate, which requires comparatively long exposure to the sunlight, responded to the Roentgen rays more quickly than did the instantaneous plates, which require only a fraction of the time of exposure. Dr. W. Y. Cowl, of Berlin, has made the observation that two plates, one of which is one hundred times quicker to ultra-violet rays than the other, act with about equal quickness to X-rays. He also claims that the fine granules of the bromide of silver are more sensitive to the X-rays than are the coarse ones, which is just the opposite of the ultra-violet rays. These are not ultra-violet rays, but probably belong to a plane far above the latter.

What is the nature of these rays? Professor Roentgen stated, with much reserve, that they were longitudinal vibrations of the ether, which are vibrations moving longitudinally to the lines of propagation, thus differing from the transverse vibrations of light and heat which move perpendicularly to the line of propagation. If it is true that they are longitudinal vibrations of the ether, this gives us a new conception of the ether itself, for we have generally considered that it was non-compressible, capable only of transmitting transverse vibrations. If, however, we find that it transmits longitudinal vibrations, it must be slightly compressible.

Others advance the theory that the rays are lines of magnetic force. Mr. Tesla believes that they

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are actual particles of matter forced through opaque substances, and that their actinic action upon the plate is mechanical; he states that there are certain chemicals which are very sensitive to such mechanical impressions, and suggests that they be utilized to demonstrate the truthfulness of his theory; but, so far as is known, these experiments have not been successful. However, the recent discoveries by Prof. J. J. Thompson of the minuteness of the particles, the cathode ray being one thousand times more minute than the atom hydrogen, may add new force to this theory.

It has long been known that lightning and large sparks of electric discharges are capable of producing effect upon sensitized photographic plates through certain opaque substances. We now know that this effect is electrolytic. Now, if Mr. Tesla's theory be correct, these particles of matter would naturally contain a certain amount of electrical charge; and would it not be more reasonable to explain their actinic effect on the electrolytic theory, than it would on actual mechanical impulses? The fact that they are capable of conducting electricity is proved by their ability to discharge an electrolyzed plate, as shown by Roentgen's second article on the subject.

Various experiments have been made to obtain the Roentgen rays other than by the Crookes tube. It has been claimed that they emanate from an arc light, or from the disruptive discharges from the poles of a static machine, or from bolts of lightning, as has been cited. In carefully comparing the ray obtained by the arc light with the Roentgen ray we

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find, in the first place, that it is very much weaker in its power of penetration, and that the laws of penetrability are not the same. For example, while color, with perhaps the one exception of ruby, has no effect on the Roentgen rays, so far as we know, it has on the arc light rays, for two pieces of celluloid of the same thickness and density, one white, the other red, conduct the arc light rays differently. We are sure we are voicing the opinion of ninety-nine out of a hundred scientists, who have experimented on the subject, when we say that Roentgen rays have been produced only by radiation from an excited Crookes' tube except, perhaps, by radium.

Most interesting are the laws governing the penetrability of these rays. In this connection it was at first thought the opacity depended upon its density. This was soon disproved, for substances of similar density revealed great variations in opacity. Bone, which was thought to be very opaque, has been found to be more transparent than lead, for lead bullets within bone are easily detected by their greater opacity. Platinum is the most and aluminum the least opaque of the metals. The opacity of glass seems to depend largely upon the amount of lead it contains. The abdominal and thoracic viscera, as well as the brain,—the kidneys excepted, which seem to be more opaque,—are quite transparent. Certainly the transparency of all materials depends upon the length of exposure as well as upon the force and quality of the rays. There has been a law evolved governing the conductivity of all bodies to X-rays, and that is, "the penetrability varies inversely as the product of the atomic weights by the specific gravity."

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Heat and light vibrations are the same, only differing in the amplitude and velocity of their vibrations. Certain substances will conduct heat vibrations and not light, while others will conduct light and not heat. In a lecture delivered in the Senate House before the University of Cambridge, May 16, 1865, Professor Tyndall described a series of experiments he had instituted to study the conductivity of vapors of various substances to heat and light vibrations. By placing these in a vacuum and allowing the vibrations to pass through them and to concentrate upon one side of a thermo-electric pile, the variations of the galvanometer needle, which was connected with the pile, told the amount of heat that passed through the various vapors. He was thus able to make certain observations, and found that when a substance transmitted a vibration, the amplitude of its molecular vibrations had to correspond to the amplitude of the ether vibrations.

We know that the soft parts of the human body have a molecular vibration. It is claimed by many that osmosis is due simply to molecular vibration. In fact, in a recent article on the subject of osmosis the author claims that the lining or plastic material inside the cell wall, which is simply the matured protoplasm of the cell, has a certain amount of elastic vibration, that this vibration gives it the power to conduct substances which have similar vibrations, and that the selective power of different membranes in osmosis depends entirely upon this action.

Now, applying this same law of equality of molecular and ether vibrating amplitude to the

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penetrability of the X-rays of the human body, we naturally conclude that the body conducts these rays because its molecular vibrations are equal or similar, at least in amplitude, to the vibrations of the X-rays. If Roentgen's contention that these rays are longitudinal vibrations is true, perhaps the phenomenon is explained on the ground that the molecular vibrations of the body and other substances traversed by them are longitudinal. This, of course, is only a theory, but is well worth more careful study.

Not one of the least important questions is: Whence do these rays emanate? Professor Roentgen has stated that they emanate from that part of the tube which fluoresces most; that is, where the cathode rays strike the wall of the bulb, and where the radiant energy of the cathode rays come most directly in contact with the wall of the bulb. Professor Magie, of Princeton College, with a piece of lead,—which is very opaque to the rays,—with a small opening through it, was able to examine by means of a fluoroscope the surface of the entire tube; he came to the conclusion that the rays were much greater where the glass wall of the tube was thinnest, and, therefore, concluded, in support of Professor Roentgen's theory, that they came from the inside of the tube.

The theory has been advanced that they emanate from the cathode electrode, piercing the glass and going on through space; but this is easily disproved by the fact that, when the cathode rays are deflected within the tube, the Roentgen rays emanate from the deflected point. Now, the Roentgen rays are

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not deflected, and if they emanated from the electrode they would not be deflected, but would pass out from the point directly opposite. Another theory is that, as the vibrating bell within the non-exhausted glass bulb conveys vibrations to the glass, which in turn conveys the vibrations to the air outside, by which they are conducted to the ear of the hearer, so the impaction of the cathodal radiant

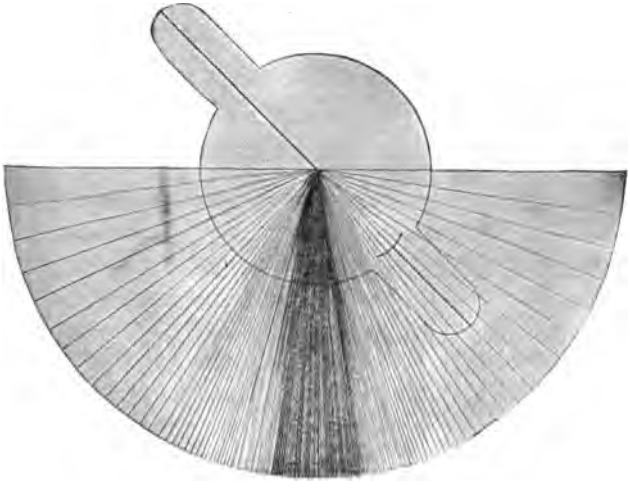

FIG. XXIX.—SHOWING THE DENSITY OF THE RAYS.

energy upon the glass produces vibrations which in turn cause vibrations of the ether outside the tube, this producing the Roentgen rays or vibrations. The thinner the glass the greater would be its vibrations. Therefore, while we can come to no definite conclusions as to the origin of the Roentgen rays, whether inside or outside the tube, we know

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that they start from that part of the tube, either inside or out, where the radiant energy of the cathodal stream fluoresces mostly.

The Electric Energy Necessary to Excite the Tube.—The first essential is to have an electrical charge or current of sufficient electro-motive force or potential to overcome the resistance of the vacuum tube. The higher the vacuum through which the electric energy can be passed, the greater will be the penetrability of the X-ray. Therefore, those machines which give off the greatest amount of voltage, or, in other words, are capable of generating the longest spark, will drive the energy through a higher vacuum, and, consequently, give a more penetrating X-ray. This may be taken from any source where the potential or voltage is sufficiently high. There are, however, at present but two practical sources, the induction coil and the static machine. Each has its strong advocates. The coil is far more portable. For instance, in a hospital it may be easily moved to a bedside, and, furthermore, it will generate electricity in all kinds of weather without trouble to maintain it in condition. On the other hand, the static machine may be used for the double purpose of X-ray and static treatment.

Various meters have been constructed to measure the amount of current that passes through the tube. This gives the actual amount of current passing through the tube, but it does not give an idea of the quality of the X-ray given off, as there are many other facts to be taken into consideration. A certain amount of current passing through one tube may produce, when passed through another tube,

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an entirely different effect, so far as the quality of the X-ray is concerned.

The Fluoroscope. — Although Professor Roentgen first made use of the fluorescent screen, we believe that the construction of the fluoroscope, and the uses to which it is now put, belong independently to Professor Magie, of Princeton College, and Professor Salvioni, of Perugia, Italy. Neither can claim priority, but both may claim originality. The

FLUOROSCOPE, WITH BARIUM-PLATINO-CYANIDE SCREEN.
FIG. XXX.

instrument, Fig. XXX, consists of a device or box of any material which will shut out the light, across one end of which is placed a paper covered with crystal of tungstate of calcium or platino-barium cyanide. The fluorescent side of the screen is placed inward or toward the open end of the device, the other side being covered with cardboard to protect it. Now, if the eyes of the observer are pressed closely into the open end of the fluoroscope so as

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to prevent the light from entering,—unless it be in a perfectly dark room, when this is not necessary,—and an excited Crookes' tube be held so that the X-rays stream toward the closed end, they penetrate the cardboard and produce on the screen a fluorescence plainly visible to the eye. If, now, a block of wood be brought between the tube and the fluoroscope, the rays penetrate it and produce the fluorescent effect upon the screen. If the hand is substituted for the block of wood, the rays penetrate the flesh, leaving a distinct outline of the bones.

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CHAPTER IV.

HIGH FREQUENCY CURRENTS.

High frequency currents are oscillating currents having such a rapid rate of alternations that the term high frequency has been applied to them. A high frequency current must have a very high electro-motive force, but not necessarily a very great intensity. These currents are usually produced by the discharge of a condenser, such as a Leyden jar, through a small inductorium in the cir-

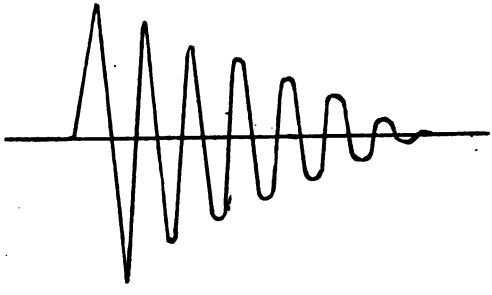

FIG. XXXI.

cuit. In order to obtain the highest rate of oscillations, the discharge must be from a condenser not too large, and through an inductorium of small resistance. A discharge from a pint-sized Leyden jar through an inductant of small resistance, will produce a much higher frequency of alternations than would a discharge from a quart-sized Leyden jar through a correspondingly large inductant. On the

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other hand, however, the amplitude of the vibration from the large jar would be much greater, and the amount of discharge would, of course, be correspondingly greater.

It seems that a large quantity of current, or a great resistance in the inductant, acts as a dampner on the frequency of alternations, just as a weight attached to a pendulum acts as a deterrent on the frequency of its oscillations. The characteristic of these alternations is that they disappear in a descending order, as illustrated in Fig. XXXI. This may be better understood by comparing the oscillations of a flat piece of thin spring steel, fastened securely at one end. If the free end be suddenly turned to one side, Fig. XXXII, and then freed, it will, by its own elasticity, swing beyond the median line in the other direction, but not quite so far as it was pressed in the first direction; here its flexibility causes it to reverse and swing beyond the median line in the opposite direction, or in the direction it was first pressed, but to a less distance than it passed in the first direction; and so on, each oscillation decreasing a little until the spring comes to a stop. These descending oscillations of the spring are the same as the descending alternations of a high frequency alternation. If, now, the thin steel spring be replaced by a thicker one, the oscillations will be much less. This increased thickness, or loss of elasticity in the spring, is similar in results to the increased resistance placed in the circuit, such as a smaller or longer wire used as an inductorium.

A more perfect simile of the actual working of a high frequency machine, may be had by taking two

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vessels partially filled with water and connected by a pipe. By violently agitating these vessels from side to side the water will run through the pipe,

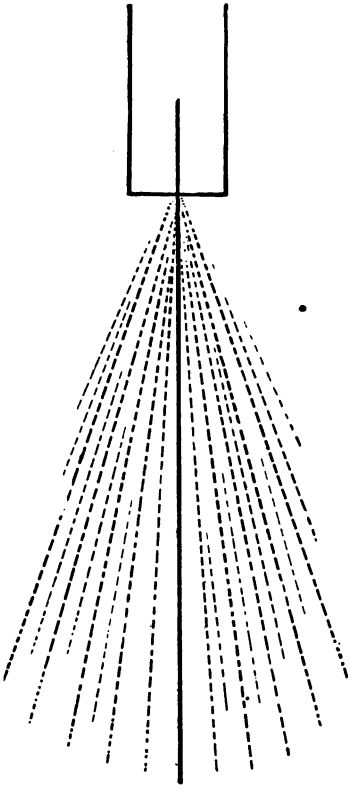

FIG. XXXII.

rising to a higher level in one, and, consequently, lowering the level in the other. The water, however, does not remain thus, but rushes back, again

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raising the level in one vessel and lowering the other correspondingly. This causes the water to rush back again, and so on, making several surges through the pipe, to and fro, each time receding from the highest level raised in the respective vessels, until it finally settles down to a normal level on each side.

If we connect to the outside coatings of two Leyden jars a few turns of short, thick, copper wire, as in Fig. XXXIII, which is known as a solenoid, we have what is known as the D'Arsonval apparatus. Suppose the outside coatings of one of these jars to be charged positively, and the other negatively.

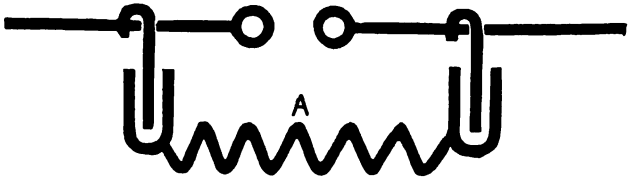

FIG. XXXIII.

Now, as a spark passes at the terminals, thus neutralizing the charges on the inside of the jars, the charges on the outside being released, rush through the solenoid, going from the higher potential, or positive charge, to the lower potential, or negative charge. Instead, however, of these charges being neutralized at one discharge, there is an extra rush, and the negative jar becomes positive and the positive negative, but to a less degree than the original charge. A reversal now takes place, and this again reverses until they exactly neutralize, just as the

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water in the two vessels finally reached a uniform level.

These discharges backward and forward through the solenoid build up by self-induction extra currents which we utilize in the administration of high frequency currents. The apparatus here described is known as a D'Arsonval coil. Now, if a resistance, or a screen, be put in the pipe connecting the two vessels before described, the number of the oscillations of water would be less. The same would be the result if the wire of which the solenoid was made long and thin, thus increasing the resistance. An idea may be had of the enormons rate of these alternations, when it is estimated that the discharge from a Leyden jar of a pint size, when only a short, thick wire is used to connect the external and internal coatings, is 15,000,000 periods per second.

The method of producing high frequency currents for medical use is by discharging the condenser—Leyden jars—through a small inductorium. Fig. XXXIV represents one form of high frequency apparatus, The Leyden jars, B B, may be charged from a static apparatus, from a coil, or from any source which gives off a charge of sufficient potential. As most electro-therapeutists possess a static apparatus, this is easily managed, but it should be stated that much greater effects are produced by a large coil than from the largest static machine. As the jars become charged with a sufficient electro-motive force to overcome the resistance of the air-gap at s. s. a spark passes, emptying the jars. This releases the charge from the outside coatings, and it rushes through the con-

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ductors a. a. to the primary coil. This coil is made up of only a few turns of wire, and the secondary coil, which is wound over it, is composed of more turns than the primary coil, is of fine wire, and is separated from it by a tube of pure Bohemian glass to prevent sparks passing between the coils. Now,

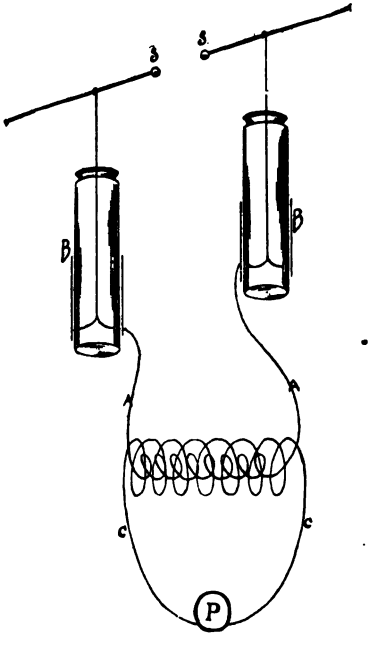

FIG. XXXIV.

instead of one discharge here, there are millions of oscillations to and fro; with each of these oscillations, a corresponding current is induced in the secondary coil, of even a higher potential than those which come from the condenser.

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The insulation of the wire must be very perfect. In large apparatuses of this kind it is necessary to immerse these coils in oil, but not so with those used for medical purposes. The glass tube insulator must be of the best quality, or it will become fractured and the coil is no longer of any use. If we should use larger coils and correspondingly larger

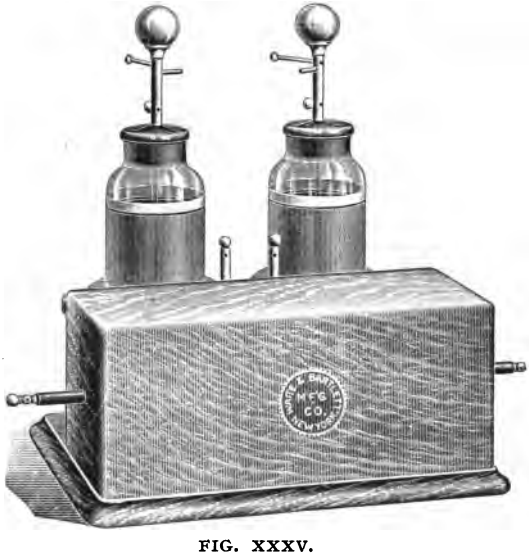

FIG. XXXV.

sized Leyden jars, we should get a larger current giving greater amplitude, but with less frequency. The electro-motive force is also greater according as the distance of the spark-gap at s. s. is greater. This would also increase the amplitude of the oscillations. Such an instrument is illustrated in Fig. XXXV and is known as Piffard's hyperstatic

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While induction, or, rather in this case, self-induction, is the most important factor in the working of the instrument, there is also another principle involved and which has been termed by Oudin as tuning. He believed the secondary coil, or rather that part of the coil above the selector, the end of which terminates in the ball on top from which the effleuve is given off, acted with the primary coil just as the tuning fork acts when another is brought near it, and vibrates to the same key. If a tuning fork be made to vibrate, and another, tuned to the same key, be brought near, the second one will be found vibrating the same as the first. Oudin claims, therefore, that the secondary, top windings must be capable of reaction to the same vibrations as the lower windings, or those which are separated by the selector; or, as he puts it, keyed to the same electrical pitch.

If this be true, it would seem that a better comparison could be made with an organ pipe. If a node be formed in the lower end of an organ pipe, other nodes will form above giving the same length of vibration, provided the pipe be of the right length; otherwise, an inharmonious sound is the result. Now, if this node be moved up or down until it is so adjusted that each node gives the same length of vibration, the pipe gives out one harmonious note. The same law seems to govern the action of the Oudin resonator. There will be no harmony in its action if the selector which taps off the lower turns be moved above or below the node, but when the node is finally struck the instrument works in harmony, and a tremendous effleuve is given off from the ball at the top. The node

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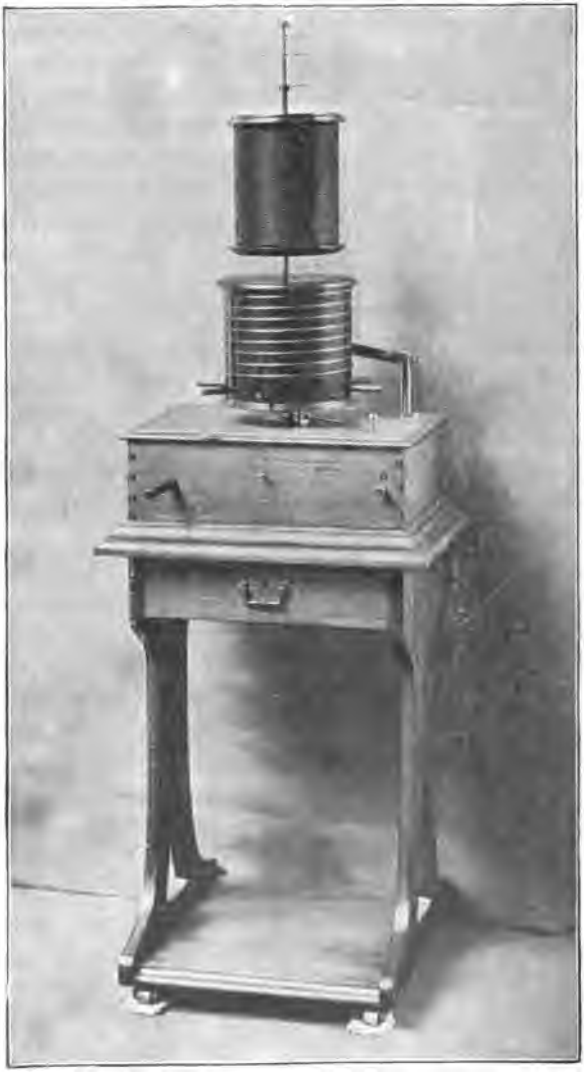

FIG. XXXVII.—HIRSCHMANN TYPE OF HIGH FREQUENCY APPARATUS.

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changes when electrodes are attached to the ball, and it will also change according to the capacity and form of the electrode. A glass vacuum and a glass

FIG. XXXVIII.—OVINGTON TYPE OF HIGH FREQUENCY APPARATUS.

condenser electrode of the same size will require slightly different adjustment of the nodes to get the

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maximum effects. Each operator must work this out for himself with his set of electrodes.

This is the instrument with which the physiological experiments have been made, and the therapeutic results, so far as Europe is concerned, have been obtained. Whatever may be its action, however, it is certainly a powerful and efficient instrument, and one that can be easily kept in working order.

FIG. XXXIX.—HOT WIRE MILLIAMPERE METER.

Many modifications of high frequency generators are on the market. As a rule, these are constructed along somewhat dissimilar lines, but they work out about the same results, some possessing more or less advantages in some particulars.

Milliampere Meter for Measuring High Frequency Currents.—For a long time it was not thought necessary to

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use a milliampere meter for measuring high frequency currents. Of late, with the more extensive use of these currents, it has been found that the alternating milliampere meter is just as necessary as are the meters for measuring the direct current. It is known as the hot wire meter. When electricity, either direct or alternating, passes through a poor conducting medium, heat is generated. The meter used for high frequency alternating currents utilizes this fact. A piece of wire composed of a mixture of alloys of platinum and iridium is so arranged that when the current passes through it, it becomes heated, and consequently elongates. By a simple mechanical device this elongation is made to turn the pointer of the instrument, the degrees of heat generated in the wire being translated into measurements of milliamperes.

This instrument, if well constructed, is quite accurate, and measures from the smallest to the largest amount of current needed. It is only used in the general administration of high frequency currents, and not in the local application with the glass electrode.

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CHAPTER V.

THE WHITE LIGHT—ULTRA-VIOLET LIGHT—FINSEN LIGHT.

Of these names the first, as will be seen later on, is the most appropriate. An ordinary shaft of white light, when passed through a piece of wedge-shaped glass or prism, is divided into various colors. This is due to the fact that different colored rays differ in their refrangibility, and only by an admixture of these colors can white light be produced. As red rays are the least frangible, they are found at one end of the spectrum; and as violet rays are the most frangible, they are found at the other end; yellow, green and blue rays filling in the intervening spaces. If we examine more closely the rays which make up these various colors, we find that their vibrations differ in amplitude, or the distance each traverses to and fro; and also in the rate of vibration, or in rapidity. The red light is supposed to make about four hundred billion vibrations per second, while the violet ray makes about eight hundred billions per second. Therefore, the visible spectrum varies from four hundred to eight hundred billion vibrations per second.

On still closer examination we find that beyond the red there are rays which are invisible; these are known as the infra- or ultra-red rays, and they have a rate of vibration of less than four hundred billions per second. These rays contain nearly all the heat

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there is in a shaft of light; the red rays contain very little heat, and this is still less in the yellow, green and other rays, and is practically lost in the violet We also have invisible rays beyond the violet, which are known as the ultra-violet rays, and have a greater vibration than eight hundred billions per second. Just as the heat decreases from the red end of the spectrum toward the violet, so does the chemical action of the rays increase as the violet is reached. The greatest chemical action is from ultra-violet rays as the greatest heat is from the ultra- or infra-red rays.

On the assumption that it was the violet and ultra-violet rays only that possessed therapeutic properties, many different lamps have been devised which give off violet and ultra-violet rays. It was, however, soon discovered that treatments with these lamps did not produce the good results that were obtained when the entire shaft of white light was used. Further experiments have proved that while the violet and ultra-violet rays apparently have the greater germicidal action, this action is limited largely to the surface, as when the germ is placed on a glass slide; when germs are imbedded in the tissues even slightly, these rays have not the power to penetrate to them.

It was soon discovered at the Finsen Institute that all the rays of the spectrum were needed to produce therapeutic results, except, perhaps, the infra-red rays, and these are filtered out. While, of course, none of the rays of the spectrum are capable of penetrating as even a weak X-ray can, the red and yellow rays, nevertheless, have the power of

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penetration to a degree, and carry the violet and ultra-violet rays with them. It has been found that violet or ultra-violet rays are seen less in solids; this is especially true when filtered out by themselves. It is probably owing to this fact that they are capable of passing through glass only to a very slight degree, even if the glass be not over-thick. Therefore, the focusing lenses of the lamps and pressure buttons, in fact, every transparent object through

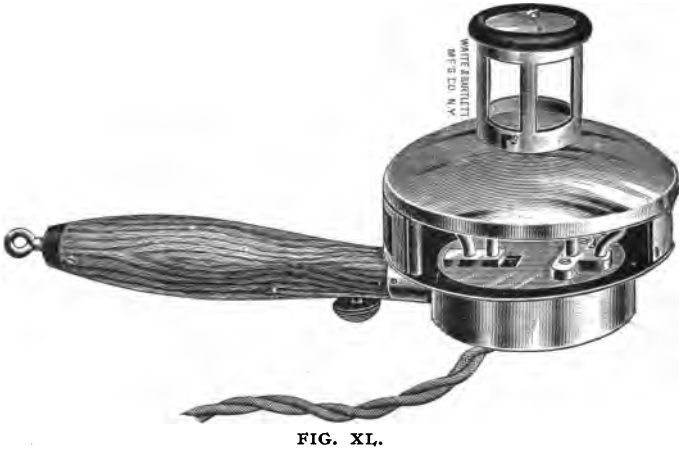

FIG. XL.

which the light passes, must be made of other material than glass. Quartz,—rock crystal,—conducts violet and ultra-violet rays freely, and therefore, this is used for the construction of the lenses of the Finsen lamp,

As there have been other than Finsen lamps put upon the market by different makers for the purpose of giving the Finsen treatment, mention of two of them may be made before proceeding to describe

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the genuine Finsen apparatus. One known as the Bangs lamp is an ordinary arc light lamp, in which the two terminals are made of iron instead of carbon. As the iron burns away very slowly no device for its constant regulation is needed. The lamp shown in Fig. XL is a modification of the Bangs lamp by Dr. H. G. Piffard. This is self-cooling and simple to operate. Enough resistance should be put into the circuit to cause the lamp to burn with a steady violet light. The iron electrodes are then approached until contact is made, and allowed to separate sufficiently to form an arc. The radiations given off from this lamp are very rich in violet and ultra-violet rays, and these are about the only rays that are given off, there being scarcely any red or yellow rays. This lamp has been tried in the Finsen Institute, and has been pronounced a failure, so far as its therapeutic properties are concerned. Still there are those who claim to have had excellent results with it. Certainly, the cheapness of the lamp, both as to original cost and operation, is a strong recommendation for it.

Another of these lamps is the Görl. The lamp shown in Fig. XLI is a modification by Dr. H. G. Piffard, and it is more efficient than the original lamp constructed by Görl. Light rays are here produced by the discharge of a very high potential current from either a Rumkorff coil, or from a large static machine through a multiple spark-gap. Its maximum effects are obtained when used on a coil and a condenser, such as a Leyden jar placed in the circuit parallel with the lamp. This is done by attaching the poles of the coil, one to the inside and

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the other to the outside of the condenser, and then connecting the two rheophores of the lamp directly to the poles of the coil. The radiations from this lamp are also very rich in violet and ultra-violet rays.

Dr. Piffard claims to have discovered another ray unknown in the other forms of lamps, and possessed of great therapeutic properties. Just what the ray may be he is not at the time of this writing able to say. His method of giving the ray is to use no quartz or glass over the light, but to allow the rays

FIG. XLI.

to impinge directly upon the affected part. So far as the author knows this lamp has never been sufficiently tried for therapeutic purposes to warrant conclusions regarding it. Finsen has never given it a thorough trial, and it is not even considered a possibility at the Finsen Institute. In Germany, the home of its birth, it has received no consideration, and it is only now beginning to have trials in America in order to demonstrate its merit.

No one has a right to condemn Dr. Finsen's treatment, unless he has used the same lamp that

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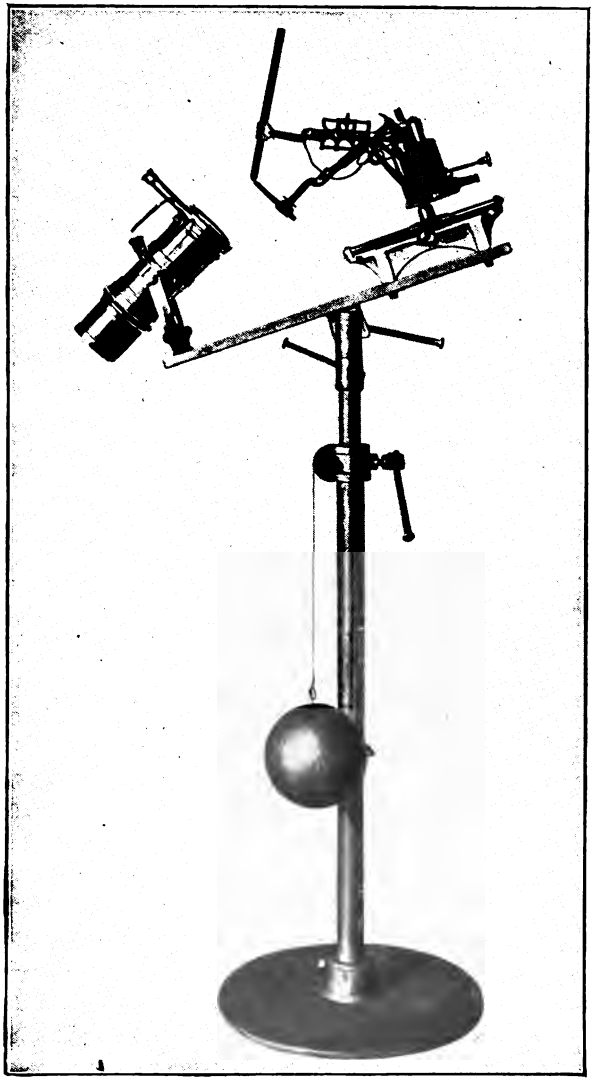

FIG. XLII.

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Finsen used, and follows out his precepts. At the Institute in Copenhagen very large lamps are used, from which project five tubes. Another lamp made with only one tube leading from the arc is also used, both in the Finsen Institute and in the London Hospital. Fig. XLII is an illustration of such a lamp. It is known as the Finsen–Rhyne lamp, and possesses all the properties of the five tube lamp. Fig. XLIII is a schematic representation of the tube lead-

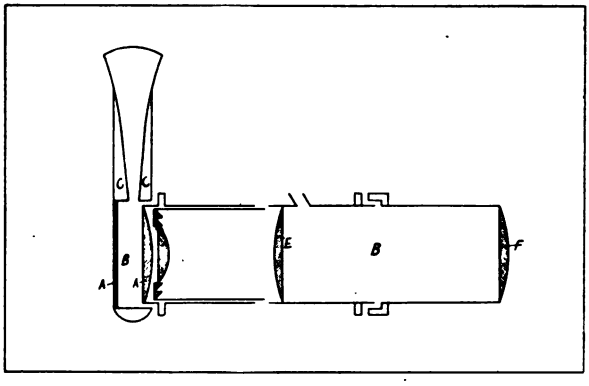

FIG. XLIII.

ing from the arc, which is two feet long, and contains four rock crystal lenses and one plain sphere. Beginning at the left, which is the top of the tube, or the one nearest the light, AA represents a plain sphere at the end, and two simple converging lenses one and one-half inch further down the tube, placed in parallel. The space B contains distilled water, surrounded by a chamber through which it is con-

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stantly flowing in and out, insuring its coolness. About midway of the tube is another converging lens E. The function of the first two lenses is to collect the light. The rays from an electric arc light are divergent instead of parallel, as is the sun's rays; therefore, a set of lenses must be introduced to first render these rays parallel, and this is the function of the first pair of lenses. The rays, thus made parallel, are capable of being focused, the same as the sun's rays. This is done by the two other lenses, E and F. The space, B, between the two latter lenses, is also filled with distilled water. The light passes through two more lenses, known as the compressure glass, which is also filled with running water. It must, however, be remembered, that all these lenses must be made of rock crystal, as glass does not permit the violet and ultra-violet rays to pass through it. The spectral colors are present in the rays, which are emitted from the distant end of the tube, but the infra-red or heat rays have been either filtered out, or cooled to such a degree that there is no danger of burning the patient. This individual lamp is made to run on a 55 volt circuit, and consumes 20 amperes of current. It is comparatively easily handled, but the lenses must be kept scrupulously clean, so as not to impede the light. How this instrument is used, and the care required to keep it in perfect order, is best set forth in Finsen's own words, as sent out by the makers of the lamp:

HOW THE INSTRUMENT IS USED.

1. The stand is adjusted with care and fastened in a suitable position.

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2. The upper and lower parts are filled to the brim with distilled water.

3. The circulating current of water is turned on, taking care that there are no bends in the rubber tubes.

4. The carbons in the lamps are adjusted, so that the point of the thin lower (negative) carbon nearly covers the point of the thicker upper (positive) carbon.

5. The lamp is pushed forward until the carbon points are about two inches from the collecting instrument. This is adjusted so that the carbon-points are right opposite the centre of the nearest rock crystal plate and are fixed in this position.

6. By means of the carriage the lamp is again moved away as far as possible and is now lighted. (It burns at first with a very unsteady light and a large flame, which would burst the lens, if brought too near.)

7. When it burns steadily, it is again very slowly brought to within a distance of about two inches from the collecting apparatus, and the correct adjustment is thus nearly obtained.

8. The precise adjustment is reached by holding a piece of white paper close in front of the lower lens, when a powerful round spot of light will be seen, which fills the whole lens, except the outer one-half centimeter (*i. e.*, the round spot of light on the paper must be exactly central and the one-half centimeter smaller in diameter than the diameter of the lens). To attain this it is generally necessary to move slightly one way or the other both apparatus and lamp.

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9. The accompanying perforated cover is put on the lower end of the instrument, and the patient is so placed that the compressor will be a little inside the focus.

10. The cover is removed and the treatment is begun. Gradually, as the carbons are burnt, the lamp, by means of the rachet, must be moved (about every ten minutes) a little nearer the apparatus. In addition, the proper adjustment may be observed by holding white paper before the lower lens. To be sure that the light does not burn the patient, see that the water is constantly circulating.

When the treatment is finished, the lamp must be extinguished before the water-current is shut off. As the distilled water contains quite a large quantity of air, before use, it must be boiled in an enameled kettle that is only used for this purpose. When cooled the apparatus is filled.

HOW THE APPARATUS IS CLEANED.

The apparatus must be cleaned daily.

For this purpose use two corks, fastened on the ends of two wooden rods with a nail in each, which must be driven so deeply into the cork as not to scratch the lenses. Polishing crocus (pulv. lapis hæmatides) and diluted muriatic acid may also be used if necessary.

Proceed as follows:

1. The apparatus is taken apart in three sections. After this the lower and upper sections are each unscrewed into two parts.

2. The inside surface of the two lenses are rubbed with one of the corks under a continuous stream of

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water; they are then immersed in common water, and at last in distilled water.

3. In case the lenses are not clean the other cork is lightly dipped in polishing crocus, and the lenses are rubbed with it, and afterwards washed while being washed with the first cork, which must not come into contact with anything but clean water.

4. In case there are deposited salts, which have not come off by the two above mentioned cleaning methods, by means of the cork dipped in diluted muriatic acid, the lens may be rubbed and afterwards *well* washed to remove all the acid.

Never allow the acid to come directly into contact with more of the apparatus than the lenses by means of the cork, as it dissolves the substance of the putty with which the lenses are fastened, and besides makes the distilled water cloudy.

5. The corresponding parts are screwed together so that the *rubber rings fit in a water-tight manner.*

6. The outside lenses are wiped with a cloth (the sides of the lenses toward the water must never be wiped, as that leaves particles of grease and flues, which makes the water unclear).

The upper part of the apparatus can at times be leaky, making it impossible to use the whole instrument before it is repaired; it is therefore necessary to have a reserve part, so as to avoid a longer interruption of the treatment.

To prevent leaking it is well, when the apparatus is not in use to empty the instrument of the distilled water, so that it may be dried. The compressors are cleaned in the same manner.

Note: If one of the screws cannot be loosened,

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the reason is, that one of the rubber rings has adhered to the metal; it can be loosened carefully with a knife.

The lamp known as the London Hospital lamp simply has the two lenses nearest the arc, the same as in the lamp shown, and no other; all these lenses do is to make the divergent rays of the arc parallel, but do not focus them, which is absolutely necessary. This lamp does not enjoy any special reputation, even at its home, the London Hospital.

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CHAPTER VI.

RADIUM.

Radium is the product of the growth of that science which was first set in motion in the 70's by the researches of Sir William Crookes, and later advanced by Hertz, Lenard, Roentgen, Henry and Becquerel.

The year after Roentgen discovered the X-rays, M. Henry made some experiments to ascertain if similar rays could not be made to emanate from certain substances. He discovered that zinc sulphide, long known to give off visible rays after exposure to sunlight, also gave off invisible rays which were capable of penetrating opaque objects, such as paper, and also of producing actinic action on a photographic plate.

Becquerel, in making experiments along this same line, discovered that salts of uranium were capable of giving off fluorescence by some power within, it not being necessary to expose it to light. If the uranium salts were crystalized in the dark, and kept in the dark, they were capable of emitting invisible rays which would penetrate opaque objects, and act on a photographic plate. Becquerel further discovered that these rays, like X-rays, would discharge negatively electrified bodies.

Sir William Crookes, in investigating the subject further, discovered that it was certain impurities in the uranium which gave rise to the Becquerel radia-

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tions. Madam Curie, of Paris, who was at this time working on a thesis for her degree at the University of Paris, the subject of which was fluorescence, took up the study of uranium, and further discovered that some of these impurities could be separated. At this stage, her husband, Professor Curie, began working with his wife. He had refining works built at Ivry, just outside the city of Paris, and carried on a process of refining until he produced radium. His wife had previously succeeded in separating a radio-active substance which she named polonium, after her native country, Poland, and which also had powers of emitting invisible rays.

It should be stated at the outset that radium does not exist in a pure state, but in combination with radium bromide, radium chloride and radium nitrate. The pitchblende from which radium is extracted, contains about 81 per cent. of uranium. Lead, iron, barium and calcium, together with traces of other impurities, make up the remainder. Of this, radium is about a 1–1600th part. When the uranium has been extracted the residue is fused with carbonate of soda to dissolve in hydrochloric acid; after being treated with hydrogen sulphide, so as to remove the precipitable metals, there is left a barium chloride which contains the radium. If what remains in the solution be allowed to crystallize, the radium chlorides crystallize before the corresponding barium salts. Now, if these first formed crystals be re-dissolved, and the first crystals that form be again collected, they are very much stronger in radium chloride and radio-active matter than the crystals that were dissolved. This process of re-

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dissolving and gathering the first cystals that form may go on until the product obtained will have a radio-activity one million five hundred thousand times stronger than was the first specimen of uranium salt with which Becquerel made his original experiment, and which is used as the basis on which to estimate the radio-active power of radium. According to Professor Curie, it requires eight tons of the uranium residue to produce fifteen grains of pure radium chloride.

The radio-active power of radium may be detected in three or more ways. One is the quickness and thoroughness with which it affects a photograph plate. Another is the penetrability of its rays through various thicknesses of copper, and the production of a fluorescence on an ordinary X-ray fluorescent screen. The best method of testing the radio-active power is to make what is known as an electroscopic test. Fig. V illustrates an electroscope with its gold leaves made divergent by an electrical charge. In ordinary conditions these leaves will remain divergent for some time, owing to the insulation of the surrounding medium. When radium rays permeate any space they cause that space to become a good conductor; when radium is brought in the vicinity of the charged electroscope the insulating medium becomes a conductor and the leaves collapse, the suddenness of this collapse indicating the power of the radium.

Radium is a grayish powder in appearance, is soluble in water, and is very heavy, its specific gravity being about 225. It gives off both emanations and radiations.

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Emanations.—By some authorities the emanations are supposed to be of gaseous formation, and it has also been claimed that radium gives off emanations that are both gaseous and solid. Whatever may be the nature of the emanations, they do not go through glass, and it is only when an opening is made into the receptacle containing the radium salt that they manifest themselves. These emanations which are capable of manifesting themselves by bombarding a screen, as in the Crookes spinthariscope, and are also condensed by cold, are capable of going through an opening, it is said, so small that it will retain a vacuum. It is probably these emanations that impart radio-activity to other substances, such as zinc sulphide, water, and so on, and not the radiation which comes through a hermetically sealed receptacle.

Crookes' spinthariscope, Fig. XLIV, illustrates how these emanations are capable of being given off, and, at the same time, bombarding an adjacent screen. The instrument is constructed with an outer tube T closed at one end. Just in front of the closed end of the tube there is placed a paper screen A, covered with zincblende, the coated surface of which is toward the open end of the tube. In front of this, again, is a fine wire, B, which supports a speck of radium salt, and still further up the tube is the lense, C. As this lense must be focused to different sights it is made so that it can be moved up and down within the tube, and for this purpose is placed on a sliding inner tube, T.T. The emanations from the radium salt suspended on the wire bombard the zincblende screen, which gives off brilliant

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little sparks, and this increases as the radium is brought nearer the screen.

Radiations.—The radiations from radium are divided into three classes, alpha, beta and gamma. The alpha rays have very little penetrative power; they are stayed by a thin sheet of paper or aluminum, and even a column of air a few milliameters in thickness; they can be deflected by a magnet, and in this respect they behave like positive charged particles, and, for this reason, are able to carry a positive charge of electricity. The beta rays have much greater pene-

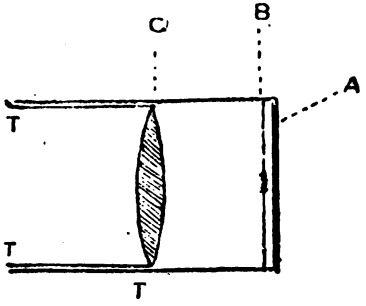

FIG. XLIV.

trative powers than the alpha rays. They are capable of penetrating thin sheets of aluminum; they are divertible by the magnet, and their behavior here shows that they carry a negative charge. If the air is exhausted so as not to conduct the electric charge off they are also capable of imparting a negative charge to objects, and from this there may be obtained a continuous stream of negative electricity, providing the ray is kept continuously directed on the part. The gamma rays have great

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penetrative powers; they cannot be diverted by the magnet; they carry no charge of electricity; in fact, they appear to be a very close form of X-ray, if indeed they are not identical with X-ray. These rays, and, perhaps, the alpha and beta also, have actinic action; they are capable of affecting a photographic plate, and the fact that the plate is affected on the other side of the hand, and other opaque substances, has proved the gamma rays possess these great penetrative powers.

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CHAPTER VII.

GENERALITIES, ELECTRO-PHYSIOLOGY, AND METHODS OF APPLICATION.

Within the last dozen years electro-therapeutics has developed along so many new lines that the subject has largely changed in character. While static electricity was used long before dynamic currents were discovered, it was for nearly a century almost displaced by its new rival. The new forms of electrical manifestations are now fast making inroads on the static, and what the future will bring forth would be hard to predict. One of the greatest drawbacks to the advancement of electro-therapeutics in the past, and unfortunately not decreasing to-day, has been the use of the agent by unqualified operators. It has been and even to-day is much used by charlatans, but these no longer have power to harm any legitimate therapeutic measure. They have been relegated to their proper place by the public and have lost whatever influence they once possessed.

To-day the man who is doing harm by the unskillful use of this agent is the practicing physician in good standing, and otherwise, perhaps, most capable in his work, who from a mistaken conception of the need of a thorough acquaintance with the subject, or what is perhaps more often true, from a desire to gain all the reward that is coming in his profession, supplies himself with an electrical outfit

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without adequate knowledge of its use. There is no branch of therapeutics where so thorough and careful a preparation is needed as this, and none demanding a wider experience in medicine. First one must fully understand the nature of the agent he is using. This takes the investigator into the almost inexhaustible field of electrical science. Not only must he be familiar with the action of all the different varieties of electrical manifestations on the human body, both fundamentally and therapeutically, but he must also have an acquired technic. That, in order to give static and high frequency treatments, less of technical knowledge is necessary, is perhaps one of the chief reasons why new comers in electro-therapeutics take up these forms of electrical application and pay no attention to the others, such as galvanism and faradism, which are, as yet, based on much more substantial facts in their physiological foundation.

All forms of electrical manifestation have their special actions and fit different requirements, just as every remedy has its special place in therapeutics. Many of these special nooks are not as yet known, but some are, and the more carefully specified indications are followed the better will be the results. The skillful operator will often be rewarded with brilliant results where the unskilled will meet with pronounced failure.

In their gross characteristics the physical properties of high frequency currents resemble the static. For this reason many believed that the physiological and therapeutic properties of both are the same. The error of such a conclusion cannot be pointed

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out too often. Not only does each differ in its therapeutical manifestation, but even the different ways each individual form is given have different properties. A simple experiment which was shown to the author by Mr. Harry W. Cox, of London, demonstrates how the physical properties of static and high frequency currents differ. If an iron cylinder be placed above a box which is divided into compartments, and one pole of a static machine be attached to it while the other is grounded, and, if now, different metals, such as copper, silver, gold, and so on, be placed on the cylinder so charged, it will be found that each metal will go its way and deposit in the same compartment. If a high frequency apparatus be substituted for the static, no such action takes place.

Observations, both physiological and therapeutic, reveal a difference in the action of these two forms of electrical manifestations when applied to the human body. The breeze or spray which may be given from the ball of an Oudin resonator, has been claimed to be the same as the breeze or spray from a static machine, but the two are very different. With the high frequency the patient need not even be insulated, and other differences might be cited. If the experiments of the French observers on the physiological action of these different forms of electrical manifestations,—one acting on nerves and the other devoid almost entirely of such action,—be true, not only are they not alike, but they are quite opposite in their action.

High frequency currents possess dynamic as well as static effects. Tesla succeeded in running a spe-

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cially constructed motor with this current. It is true that our knowledge of the physiological action and the use of these currents are as yet very empirical, but when an experimenter states that static and high frequency currents are alike, or that one can be substituted for the other, he displays a lack of knowledge of either one or the other, or, perhaps, of both.

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CHAPTER VIII.

STATIC ELECTRICITY.

Instruments for Static Treatment.—The special instruments for administering static electricity may be divided into two groups—the condenser electrodes and the non-condenser electrodes. A glance at Fig. XLV will illustrate this. It will be seen that the two groups are composed of balls and points. As a static charge distributes itself evenly over a round ball, not concentrating on any one point, it acts as a condenser in storing up a certain amount of charge, and when the potential becomes great enough to overcome the resistance of the medium between this and the patient on the insulated platform, who is charged with the opposite electrical potential, a disruptive discharge takes place. The amount of this discharge will depend upon several factors. First of all, it will depend on the amount of electricity that is being generated by the machine, as the potential of the discharge is directly proportionate to its generating power. Next, it will depend on the distance the ball is held from the patient. If the ball should be held so far away that the electro-motive force of the charge accumulated cannot overcome the distance no spark passes, but if it is held within certain limits the greater the distance between the two charges—*i. e.*, one on the patient, the other on the electrode,—just so much

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greater must be the electro-motive force in the charge in order to overcome this resistance.

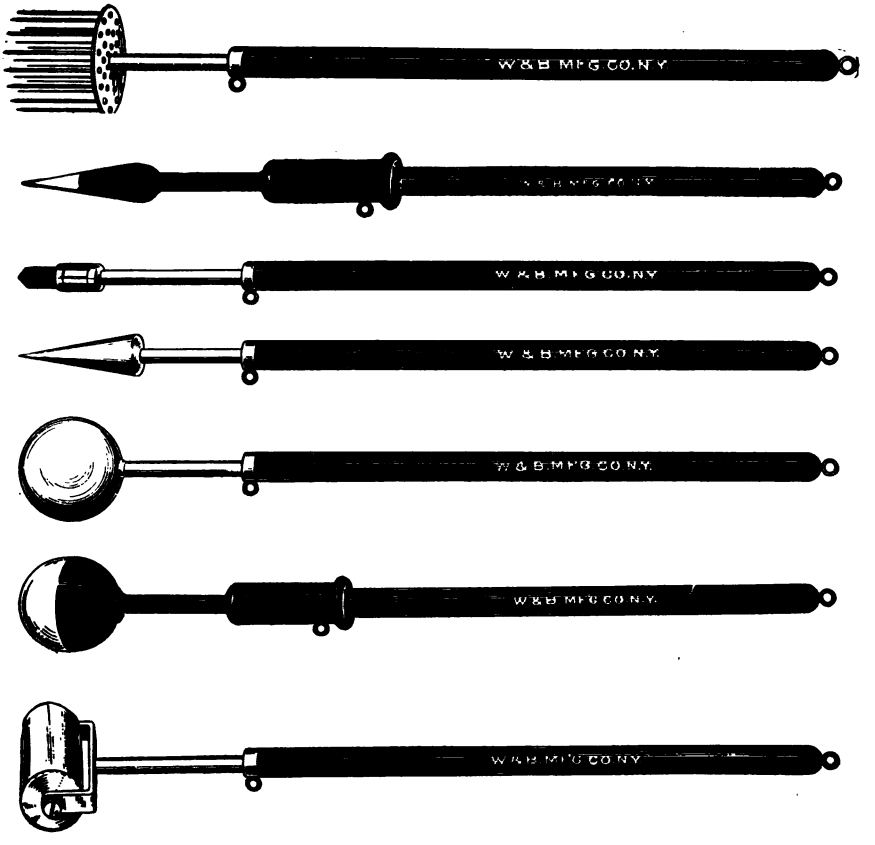

FIG. XLV.

The size and conductivity of the ball has a direct effect on the amount of the discharge; the larger the ball the better the condenser and the greater the

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discharge. With relatively poor conductors, such as wood, there is little condensation, even though the ball be of comparatively large size; instead of a clean-cut and forceful disruptive discharge, as with the large brass ball, there is a shower of small sparks, known as a brush discharge. In order to obtain this brush discharge evenly the wooden ball must have a certain quality of conductivity. One made from soft maple is best, but after lying around a heated room this will become so dried that the resistance increases to a degree that renders the ball useless. In such a case soaking the ball in water for a short time will increase its conductivity and restore it to its former usefulness. Care should be exercised not to soak it too much or it will become such an extremely good conductor that it will give large ragged sparks, which are very disagreeable.

Benjamin Franklin discovered that electric charges collected on points, and that a higher potential charge would run off a point to neutralize a lower potential charge, and *vice versa*. Therefore, the pointed electrode does not store up the charge, but allows it to pass off in a steady stream as it is generated by the machine. This method of administering static electricity is known as static breeze, and may be regulated by the number of points used and by the quality of the electrode as a conductor. The electrode with a single point will cause a greater concentration of the current than one with many points, and a brass electrode, of course, gives a much greater stream than a wooden electrode, the latter being used to treat very sensitive points, as the eye, or certain cavities or depressions in the surface.

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The roller electrode, used for giving static electro-massage or friction applications, can be easily dispensed with and the brass ball substituted for it; in fact, the ball has advantages over the roller.

Block tin, which can be cu. into any size or shape desired, is best adapted for the wave current application. For the static induced current ordinary hand electrodes, such as are furnished with galvanic or faradic batteries, are employed.

Methods of Administering Static Electricity. — The methods of administering static electricity may be divided into two groups, the insulated and the non-insulated. The insulated means that the patient is placed on an insulating platform so that the electricity may be condensed upon him. To this group belong static insulation, static breeze, spray and brush discharge, static spark and static wave currents. The non-insulated applications are the static induced and electro-static massage or friction.

Shepherd's Crook.—This is a brass rod of sufficient length—about five feet—to connect the patient with the machine. On one end is a large crook, from which the instrument gets its name, to hook over one of the poles of the machine. Each end should be capped by a round ball to prevent the escape of the charge. It may be allowed to rest on the platform, or be taken in the hand of the operator. The chains formerly used for this purpose are defective, as their many points and angles allow much of the charge to escape.

Insulating Platform.—It is important that the insulating platform should be constructed on right principles, for a defect here would be destructive

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of good results. The ends and all edges should be well rounded so as to prevent electricity from collecting on sharp angles. It should also be solidly made, and the glass legs on which the platform rests should be made of a good quality of glass and in length nine or ten inches, or even a foot, if the machine is of large capacity.

Static Insulation—Static Saturation.—This form of administering static electricity is also known as the static bath. It is a simple form of administration, and its action is mild and soothing. The patient is seated on the insulating platform, to which one pole of the machine is attached. There will be better charging of the patient if the shepherd's crook is held in the hand than if it is allowed to rest on the platform. Various gradations may be had by altering the degrees of contact with the patient. This is illustrated in Figs. XLVI, XLVII, XLVIII. For instance, if the end of the shepherd's crook be placed on the platform there is great resistance; if it be placed on a metal plate and the chair legs on this plate the resistance will be less, and, consequently, more charge, while if the feet be placed on the plate there will be less resistance and more current.

The opposite pole of the machine is grounded. There are no special indications as to the pole to be chosen for the patient. There may be some difference in the action of the two poles in administering static insulation, but at present that is not well enough defined to warrant any definite conclusions. It is claimed by some that as the normal healthful electrical state is positive, in order to restore that state

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we should submit the patient to the positive charge, which is supposed to be tonic, except where there

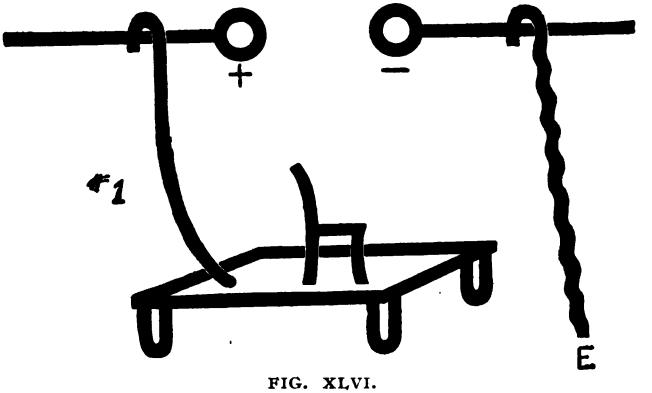

FIG. XLVI.

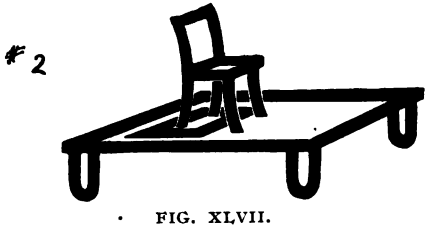

FIG. XLVII.

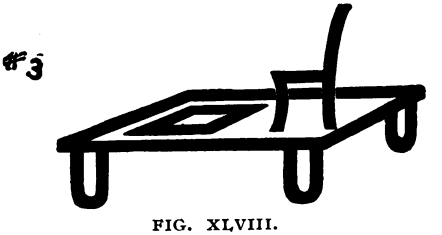

FIG. XLVIII.

is hyperexcitability, when negative insulation should be employed. This, however, is theoretical, and

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cannot be borne out by clinical experience, so far as applies to a static insulation.

In giving static insulation, if the patient is a woman, hat pins, and, perhaps, metal hair pins should be removed. Metal beads or a watch chain about the neck should also be removed. Any metals that come near the skin are apt to produce annoying sensations. Steels in corsets, however, seldom cause any trouble.

Static Breeze.—This method of administering static

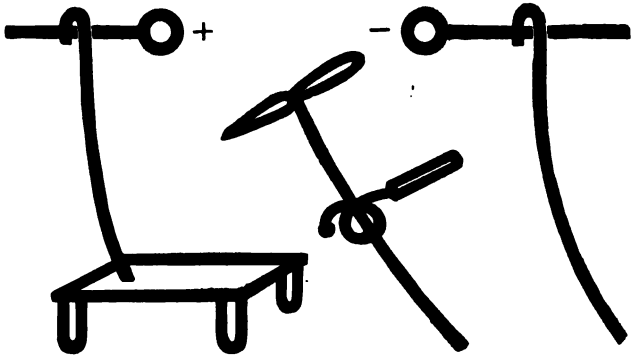

FIG. XLIX.—STATIC BREEZE INDIRECT APPLICATION.

electricity is also mild and soothing. In fact, it is the same as static insulation with the neutralization brought down to a special part of the body, and, being thus localized, it is more active at that point. The difference in the method of administering it from that of static insulation is that instead of the pole opposite to the one connected with the patient being grounded it is attached to the pointed brass electrode, which is held at a distance from the patient, so there is only a fine breeze set up between

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the electrodes and that part of the body at which it is pointed. The neutralization of the patient is, therefore, confined to a large area around the point of the electrode. When static breeze is applied to the head a large crown is sometimes used, which insures a distribution well around the entire head. One precaution should always be taken if the patient be a woman; all the celluloid pins and combs should be removed, as they are liable to ignite. Such an accident once happened to the author, and only by prompt discovery and action was a catastrophe averted.

In all the methods of static application there is not the apparent difference in the polarity of the current as there is with static breeze. With negative insulation,—that is the negative pole connected with the patient or platform,—and positive breeze,—the positive pole attached to the pointed electrode,—the application is very much more soothing than when given in the opposite direction, which, indeed, is some times irritating, and always very stimulating. In the former case the patient is charged to a lower potentiality, and the neutralization theoretically takes place on the body by the plus charge coming to the vacuum, as it were; therefore, neutralization is in all those parts of the body which contain the negative or minus charge. If we apply the same laws of neutralization to positive insulation and negative breeze we have the neutralization taking place on the electrode. This theory, however, may not hold good in practice. In one case the neutralization tends to raise the potential of the patient, while in the other it lowers it.

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As a rule there is, in these two forms of application, a marked difference in the feeling to the patient, and also in the action. An acute sciatica, or inflammation of the nerves of any part of the body, is apt to be aggravated by positive insulation and negative breeze. Aggravation may not be noted at the time of application, for temporary relief usually follows the administration in any form, but the secondary effect may be an aggravation, while the secondary effect of negative insulation and positive breeze

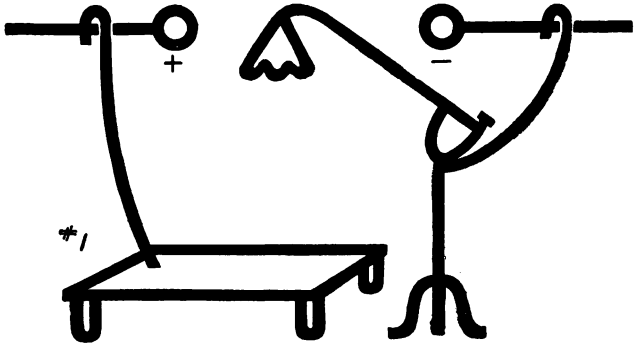

FIG. L.—STATIC HEAD BREEZE DIRECT APPLICATION.

will be soothing. The time comes when the active inflammation subsides, perhaps leaving a passive congestion; at any rate there is a lowering of the tone of the whole part. Positive insulation and negative breeze will now increase the tone, stimulate an arterial circulation and decrease the passive congestion, thereby increasing the nutrition to the part and building up the impaired tissues. It must be admitted that, in practice, conditions are met when this rule does not hold good, but not often,

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and in those cases it is quite possible there may be something about the pathology of the case that is not understood.

In the application of the breeze, as well as other forms, there is the direct and indirect. The direct application is when the pole opposite to the one connected with the patient is connected direct with the electrode; while in the indirect application the pole is grounded, and the chain attached to the electrode is also grounded. Some authors state that the chain attached to the pole of the machine should be grounded to the water pipe, while the one connected with the electrode is grounded to the gas pipe, or *vice versa*; but as there are very few houses where these two pipes do not cross each other somewhere in their distribution, making a metallic contact, little is thereby gained. As a rule, it is better to use the direct application.

Static Spray.—The only difference between the static spray and the static breeze, just described, is that the pointed electrode is held near enough to the patient to allow the discharge to become slightly disruptive; in other words, it is a very coarse breeze. Care should be exercised in giving the static spray to sensitive and nervous patients; if the electrode is held too near a spark is liable to pass, and as a spark from a pointed electrode is not clean-cut but straggling, it is exceedingly disagreeable. It is often difficult to tell just the distance that should be maintained.

Static Brush Discharge.—This is another modification of the static breeze and is a more vigorous application than the static spray. It is given with a

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wooden ball electrode, described above. It cannot be reiterated too often that the success of this treatment will depend upon the quality of the electrode used. The ball should be made of wood of even texture; it should contain moisture enough to conduct the electricity and yet not be so good a conductor as to give off sparks of volume. There should be a shower of fine disruptive sparks. The warmer the electrode the better it works. Static brush treatments can be given

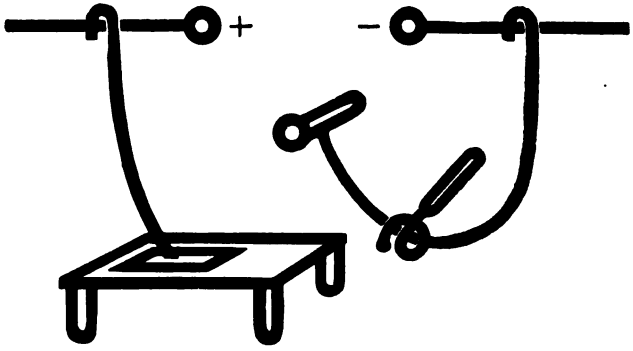

FIG. LI.—STATIC SPARK DIRECT APPLICATION.

with advantage in the summer when the weather is very humid, and when static breeze, spray, or even sparks cannot be administered.

Static Spark.—The static spark is a still greater localization of static electricity on the human body, and, at the same time, there is an increase in the oscillating vibrations that surge through the patient. In administering the static spark the shepherd's crook should not be held in the hand, as may be

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done with the static breeze, spray, or even brush discharge, but placed on the platform at a sufficient distance from the feet that sparks will not pass at the same time the spark passes between the electrode and the patient. If the patient should hold the connecting rod in his hands contractions of the forearm and arm will be produced with each discharge of the ball electrode, becoming violent when the discharge is heavy.

To successfully administer the static spark requires more skill and better technic than any other method of static administration. The spark should always be clean-cut, and not straggling and forked; the latter is not only painful to the patient, but fails to accomplish what is sought. Positive insulation with negative sparks gives, as a rule, a spark cleaner-cut than the opposite connection, and as there is as yet no well established difference in the action of the two poles in this treatment, it is better to administer it in that way. If there is a defect or a leakage in the circuit, the spark will not be clean-cut but forked. The large ball, which is both a better conductor and condenser, gives a larger clean-cut spark than the small ball, which has so small a capacity for condensing that the charge is apt to run off in a scraggly manner, and is more painful than the heavy spark from the large ball.

Sparks should not be given to the same spot in rapid succession, unless under extraordinary circumstances. Neither should sparks be given in tremendous showers, unless there be a state of anæsthesia. The best way is to give a quick swinging motion of the ball toward the patient, and quickly draw it

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back as the spark passes. This gives the appearance of the sparks being thrown off the ball on to the patient. If the machine is working well, and the circuit is not defective, these sparks will all be clean-cut, and, consequently, easily borne. The treatment is, at best, more or less severe, and should be given with great care. There are several methods of graduating the severity of the sparks. Their force depends upon the generating power of the machine, and is, therefore, greatest when the machine is a large one, and when the plates are made to revolve rapidly. The spark will also depend upon the resistance in the circuit. When the end of the shepherd's crook, which connects the patient with the pole of the machine, is placed at some distance from the feet of the patient, the spark will be less, because the dry, hard wood of the platform is a very poor conductor, and the nearer the electrode comes to the patient's feet, the greater the spark. What has been said under static breeze, and illustrated in Figs. XLVI, XLVII, XLVIII, applies with even greater force here.

When the Leyden jars are placed on the machine and their outside coatings connected, if the jars be at all large and the machine working well, the shock to the patient is terrific, and in therapeutics these great shocks are not needed. Such expedients should only be resorted to when the machine is generating badly, or the leakage is great, as in a hot, humid day in summer.

A good way to reduce the severity of the spark is to approximate the sliding poles of the machine, so that some of the charge generated is lost in a brush

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discharge between them. When it is desired to give to some places severe sparks, and to others less severe, the best method of regulation is for the operator to place one foot on the platform, the other being electrically connected with the earth; he thus draws off some of the charge, and the spark passing is correspondingly less. If in other regions more severe sparks are desired, he removes his foot, and the benefit of the full charge is obtained. In giving a patient treatment for the first time, or when a patient has been allowed to become overcharged, it is well to resort to this expedient.

Sparks are always best given through some resisting medium besides the column of air between the electrode and the patient. The resistance of ordinary woolen clothing is sufficient on all covered parts of the body, but when sparks are to be given to the hands or face—if, indeed, the latter ever be required—better results will be attained by covering them with woolen cloth.

Static Wave Currents.—This is one of the newest forms of static administration that has been brought to the attention of the medical profession. It was first described by Dr. W. J. Morton. The patient is seated on an insulated platform, the same as in the methods previously described. That portion of the body on which it is desired to localize the charges and discharges is connected directly with one of the poles of the machine, the other pole being grounded to a water or gas pipe. The sliding terminals of the machine are at first approximated, and after the machine has been started they are gradually separated, until the desired length of

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spark is reached. The electrode employed for this purpose is usually made of tin, which can be easily cut and fashioned into any shape to fit the part of the body to be treated. Long and narrow strips may be used along the spine and to cover some nerve trunk, while others of different shape are employed for special purposes. The smaller the electrode the greater will be the local effect, and, perhaps, less the constitutional. At any rate, the size of the electrode is a matter of judgment; largely a matter of the area to be covered and the condition to be treated, and also the capacity of the machine.

One rule should be followed with extra caution, and that is, the larger the electrode the longer should be the spark. This, of course, has its exceptions; the most prominent is in neuritis, especially if the nerve be superfically located. The electrode must be made to fit the part well or little sparks will pass which will cause annoyance to the patient. The edges of the electrode should be perfectly smooth, for if little points or straggly edges pressing into the skin, causing a concentration at that point, will produce very annoying sensations. When an electrode is applied to a limb a towel should be wrapped around it, binding it closely. If the electrode is applied to the back or any part of the trunk a pillow should be so placed that pressure can be made between the part and the back or arm of the chair in which the patient is seated, or if on the abdomen or chest by the patient holding it firmer. In the latter case some insulating material, such as folds of a towel, should be placed between the hands and the electrode, or the charge will go into the hands instead.

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If there is a slight burning after the electrode has been fitted to the surface of the body, this is probably because the skin is very dry, and moistening that part which is under the electrode will overcome the difficulty. The electrode should be placed over the spot on which it is desired to localize the current, although the constitutional effects are always paramount in this treatment, and it should be understood that the local effects always extend to an area outside of the electrode itself. If the liver is to be treated an electrode covering one-half or two-thirds its size will be sufficient.

The spark-gap is very important. The length must necessarily be limited to the capacity of the machine, but with those on the market to-day there is but little danger but that, if they are working well, sufficient force can be obtained at all times. The spark must be proportioned to the size of the electrode, and also to the condition to be treated.

The feelings of the patient must always serve as a guide in determining the length of the spark, especially as the capacity of machines differ. If the electrode is small and causes a sensation, nervous perhaps, the spark-gap should not be more than two to three inches in length; if it is large and causes no inconvenience, four, five, or even six inches may be attained.

So far as at present known, there is no difference therapeutically between the poles, but as positive insulation—or the positive attached to the patient and the negative grounded—is the form most pleasant to the patient, this is the best to use.

The above description gives what has been the

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ordinary method of administering the static wave current. There have been many modifications, some of which act well in certain cases. Fig. LII illustrates one of these modifications. *A* represents the patient. An electrode attached to the positive pole is applied to one side, say, the back of the chest, while another is applied to the front, and this is grounded. Here the oscillations swing back and forth through the chest.

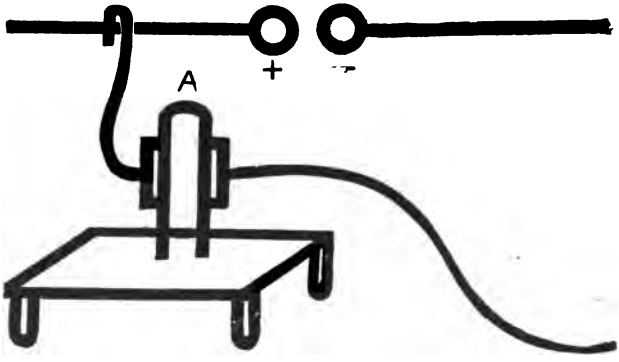

FIG. LII.

Another modification is illustrated in Fig. LIII. Here, instead of the pole being grounded direct, a Leyden jar is introduced, the outside of the jar being grounded, while the inside is attached to the pole of the machine. We get an extra condensation, and, consequently, a heavier spark. There is no special action attributed to this method of administration different from that of the ordinary method, but with a small or imperfect machine, or on hot, humid days, when a spark of sufficient length and

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volume is obtained with difficulty, this means of connecting the machine will be of great service.

Static Electro-Massage.—This is a method of administering static electricity in which there is a shower of short fine sparks given to the patient. The patient may be insulated or not. When insulated the platform is connected with one pole of the machine, as in static insulation, the other pole being attached to a large brass roller electrode mounted on a hard

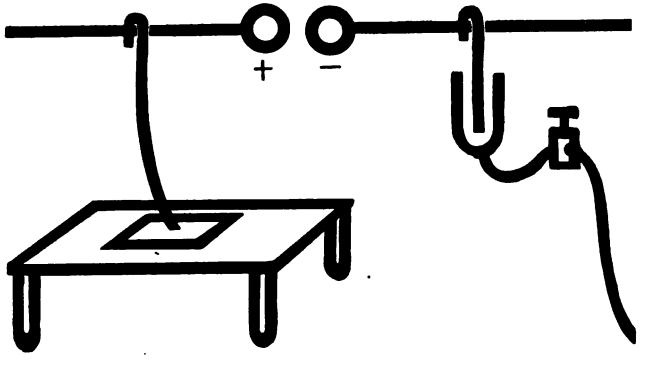

FIG. LIII.

rubber handle for insulation of the operator. When the patient is not insulated, one pole is attached to a metal plate on which the feet of the patient rest. The patient is placed in a shunt circuit, the electrode at the feet being one connection and the roller electrode, which may be moved over the body, the other. As the sliding terminals are withdrawn, thereby placing some resistance between the poles of the machine, there is a certain amount of the charge forced around through the patient. As they

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are withdrawn still further the resistance is increased between them, and more current is forced through the patient, the severity of the treatment being regulated in this way.

When the roller is pressed directly against the skin, no sensation, or but very little, is felt, as the current passes imperceptibly. When the electrode is rolled over the clothing, a shower of fine sparks, their length depending on the thickness of the clothing, is given off, causing a sharp tingling sensation. The result is a very vigorous action on that part of the integument treated. The vigor of the treatment varies with the output of the machine, *i. e.*, its capacity and the speed with which it is run, and the length of the spark which is constantly passing between the sliding terminals.

The term static electro-massage does not correctly imply what takes place in this treatment; static electro-friction would be better. The massage, which only comes from the rolling of the electrode over the body, does not amount to much. We here have a fine disruptive discharge from the poles of a static machine, and this must act largely upon the skin.

Static Induced.—This form of administering static electricity, although known for a quarter of a century, and had during the early eighties two strong advocates, Morton and Barthelow, has not come much into general use.

It is given with sponge electrodes, such as are used for ordinary faradic applications, and are applied directly to the surface of the body as in administration of dynamic currents. They are connected,

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Fig. LIV, to the outside coatings of the Leyden jars by means of ordinary but well insulated rheophores. As the sliding terminals of the machine are withdrawn a shower of sparks pass, and if we connect the inside coatings of the Leyden jars with the poles of the machine, they will become charged, and with every spark passing between the terminals, will discharge, the amount of charge they get depending upon the distance between the sliding ter-

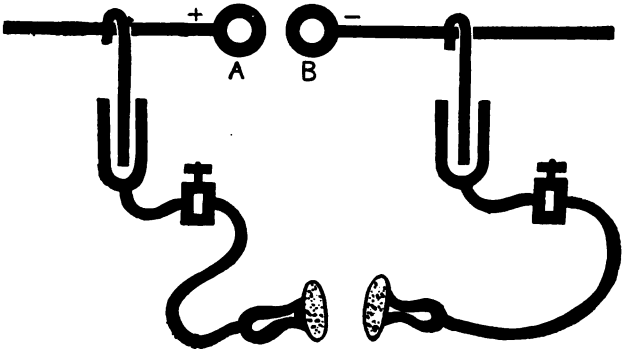

FIG. LIV.

minals. While the Leyden jars are being charged, the unbound charges on the outside of the jars are passing off quietly to the body through the rheophores, but when a spark passes between the terminals the insides empty, and there being no longer an attractive force for the bound charge on the outside, it rushes through the patient.

Here we have a true high frequency current, and the only one that is taken direct from a static machine. The charge comes from a body charged to

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a higher potential, the positive charge on the outer side of the Leyden jar that is attached to the negative pole of the machine, to one charged with a lower potential, the outside of the Leyden jar connected to the positive pole of the machine. Here, however, we have no inductant of small resistance for these high frequency currents to surge back and forth through, and to be enhanced by self-induction, but on the contrary we have a neutralizing body of correspondingly great resistance, so that the currents cannot be compared to those set up in a D'Arsonval solenoid.

Physiological Action.—We must admit that there is little physiological data on which to base the therapeutic action of static electricity. One is astonished to find that an agent so long in use, and occupying a field so broad and useful, has so little physiological foundation. Even the high frequency currents, which have been in use for only a few years, and has a field incomparably less than static, has a better developed physiological base. Static electricity has been developed, in its therapeutic uses, almost exclusively in America, and it must be admitted that in this country we have never done much in physiological research. We have not the great state institutions with their laboratories in which to make such investigation, as they have in Europe, and we also lack the temperament. We are an exceedingly practical people and have developed the practical side of this therapeutic agent far beyond any other country. The reason why it has not attracted attention in Europe, is because machines that were capable of giving off a sufficient force of electricity

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to be of any use have never been on the market there. The static machines sold by some of the best manufacturers of Europe for medical purposes are nothing more than scientific toys, such as are to be found in high school laboratōries in this country. On the other hand, electro-therapy of high frequency was developed in Europe, the first effective machines were built there, and European scientists have brought out some physiological facts which are of value in its therapeutic use.

Much has been written purporting to explain the physiological action of static electricity, but as this is nearly all speculation, it will be better to give the facts as we know them and leave posterity to work out the causes. If we did not do this in other lines we should have no science of medicine, for little prescribing is done to-day on a physiological basis. Still there are some well known facts regarding the action of static electricity on the human body which may be studied with benefit, even if the exact causes which lead up to these facts are not known. There are many plausible explanations as to how it acts in the different methods of its administration, and these also may be studied with profit.

It is a well established fact that static electricity is a great regulator of the human economy. If the heart action is above normal, due to certain nervous causes, static electricity will bring it back to the normal, or nearly the normal. On the other hand, if the heart's action is below normal, due to depression of the nervous or general system, static electricity will increase its action. While it will not increase the nutrition of a normally healthy person,

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it will increase nutrition very materially in one who has been greatly reduced through loss of certain vital forces. In other words, we find, so far as the functional processes of the human body are concerned, that static electricity will increase, diminish, arrest and modify abnormal conditions, that is, acting as a regulator.

The question naturally arises, How is all this done? Is it by an increased oxidation of the blood, or by direct action on the molecules or cells of the body, increasing the nutrition to them, and thus bringing about a normal condition? Or, does it act primarily on the nervous system, which through its vast ramifications, gives a stimulus to all the organs and tissues of the body, and in this way produces the desired result? The French experimenters, in comparing static with high frequency, found that its action was almost exclusively on the nervous system, while high frequency currents had but little action on the nerves. The question, however, is not solved.

The statement that static electricity has no chemical, electrolytic or cataphoric action is, perhaps, a little too strong. Certainly, in these respects, it cannot be compared with the galvanic, but that there may not be certain osmotic and electrolytic effects, and perhaps others which the galvanic has not, no one can positively assert. If some of the above actions are the result of static electrolization, even though to a very slight degree, when we consider the great diffusion of the changes through the entire system, the sum total would be considerable.

It has been claimed, that as static charges always

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remain on the surface of a metal conductor, they do not penetrate the human body. This, however, can be easily disproved, for a spark over a motor point of a nerve, even though that point be deeply seated, will cause vigorous contractions of the muscles it supplies. The conditions are entirely different, as the resistance of the metal ball and body are different. A charge that might spread itself over the surface of a good conductor, such as a brass ball, would have a tendency to penetrate the tissues in a comparatively poor conductor, such as the human body, and especially when the greater part of the resistance is on the surface, or in the skin. There is every evidence from the therapeutic action of static electrolization, that, when rightly given, it permeates every part of the body, and it is highly probable that its action is direct on the blood, the tissues, glands, and motor and sensory nerves. It is often stated that it increases the excretory products of the body, such as urea, but if this has been proved by well conducted experiments the author is not aware of them.

Action of Different Forms of Static Application.—The action in static insulation is simply a charge of the patient either to a higher or lower potential, according as the positive or negative pole is attached to the platform, and a neutralization of the current through the highly insulating medium of the atmosphere. This neutralization takes place mostly at angles, such as the elbows or knee caps, also from the hair. There is very little of true static oscillations here. If there is a depression in the circulation static insulation increases it. There is a regulation of func-

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tions and a slightly tonic effect. The entire body is undoubtedly diffused with the charge, and many are the ways this charge acts. It is quite possible that some of the phenomena described by Erb under the title of catalytic action of the electric current are present here in which the osmotic processes of the body and the power of absorbing nutrition are increased, for it is well kown that static insulation does increase nutrition of the body. It undoubtedly acts to a less degree in these respects than most of the other forms of application, but its mildness and soothing qualities makes its application possible to those very sensitive, nervous patients who cannot bear other forms of static application.

Static breeze has much more of an advantage in action over static insulation than to merely localize the current upon the part of the body at which the electrode is directed. There is an increase of the oscillations which go to make up the distinctive characteristic of static electricity. In fact, we have in static breeze, static spray, static brush discharge, and static spark a corresponding increase in localizations, and in the force and vigor of oscillator surging and vibratory effects, penetrating to every part and saturating every cell of the body. Besides these increasing actions, we have, when we reach the static spark, such a concentration, that it is capable of producing manifestly physiological effects on skin, muscle and nerves. From clinical observations it is quite evident that a strong static spark given over an area in which the nerve supply has been partially cut off produces a bombardment of the point of obstruction, and cause a better circula-

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tion of nerve force. This can be demonstrated in a case of locomotor ataxia where the obstruction is in the posterior columns of the spine, the static spark given over the bottom of the feet producing, for a limited period, a more normal condition.

The local effects upon the surface with a spark discharge is very marked. Several experiments have been made which prove this. Not only has it marked effects on the local cuticle, but it acts as a powerful depilatory. It also has a bactericidal action. Not always are its effects beneficial, but when given either too long or too strong it has an inhibitory, and even a destructive action on the human organism.

It is quite possible that other forms of static administration have a physiological action similar to that of the spark, but they are correspondingly less manifest on account of less concentration. It is not, however, a fair inference that, because of the less manifestation, there are necessarily less nutritional effects, and that the lack of manifestation in one or two directions narrows their usefulness, for they may have corresponding properties in other directions. Therefore, every form of static application has its indications, and, perhaps, contraindications, and these must be studied and carefully followed if we are to achieve good results.

With the static wave currents we also have surges through the body, but they differ somewhat according to the ways in which they are given. If it requires fifty thousand volts to produce a spark one inch in length when the poles are separated that distance, and one is thoroughly grounded, there

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must be accumulated on the poles of the machine an electro-motive force of fifty thousand volts before the spark will pass. With the administration of the static wave current, the patient is simply an extension of the ungrounded pole, and must, therefore, get his share of the fifty thousand volts. If the poles are separated two inches he must, provided the rule holds good, get his share of one hundred thousand volts. As the charges come and go in rapid succession, hundreds a minute, the patient is charged and discharged with equal frequency. This is proved by the vibration of the hair, which, when the discharges are not too rapid, is plainly perceptible, with every charge and discharge. With each charge and discharge there is a surging through the body of millions of oscillatory currents.

As the electro-motive force is so very great the resistance of the body need not be taken into account. No matter where the electrode is placed over the body, every cell receives its due proportion of the oscillatory currents, and each must receive a share of the vibrations. There is no doubt though that these charges and discharges have a decided local effect in the region around the electrodes. This may be proved by treating a case of a sprained ankle. If the electrode is placed over the spine, very little, if, indeed, any relief, is experienced in the ankle, but if the electrode is wound around the ankle relief is prompt and sure.

Static electro-massage probably has action similar to that of the brush or spray, so far as oscillatory discharges are concerned throughout the body, only to a less degree, but there is a more general locali-

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zation on the surface of the body. This is better adapted to skin effects than are other forms of static application, but in this regard it is inferior to high frequency currents. In fact, static electro-massage seems to be falling into disuse.

The static induced current may have a similar action to high frequency currents, which are considered in the following chapter. It is certainly far more akin to the high frequency than to the faradic current, to which it has so often been compared, even though that be from a high tension coil.

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CHAPTER IX.

HIGH FREQUENCY CURRENTS.

Methods of Administering High Frequency Currents.—There are five methods at present in vogue for administering high frequency currents, all of which are useful, varying in their degrees of usefulness. There are also modifications of these methods, but mostly differing as the exigencies of the case may demand.

Derivation — Bipolar or Direct Application.—By this method the body is put in shunt with the D'Arsonval solenoid, as illustrated in Fig. LV, B, representing the patient. The auto-induction that takes place in the solenoid increases the resistance in it, and forces through the patient much of the current derived both from the condensers and from auto-induction. In proof that a large part of this derived current passes through the patient, a hot wire milliampere-meter placed in the current will register from 100 to 500 milliamperes, according to the current generated. If an electric incandescent lamp be placed in series with the patient it will glow brightly.

Derived currents may be given simply from hand to hand, as by holding metal electrodes connected by means of a rheophore on to each end of the solenoid. The body gets little here. The best method of administering derived currents, where the entire body comes under their influence, is to immerse the feet in water, the same as in general

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faradization, and place a metal electrode on the back of the neck or over the chest. It may be given labile over the body, but one must be careful to get good contact with the movable electrode, or sparks will pass, causing an uncomfortable feeling.

This treatment produces powerful constitutional effects, and care must be exercised with it, as fainting is often the result of too long exposure. Pains, especially sciatica or neuralgia, are often aggra-

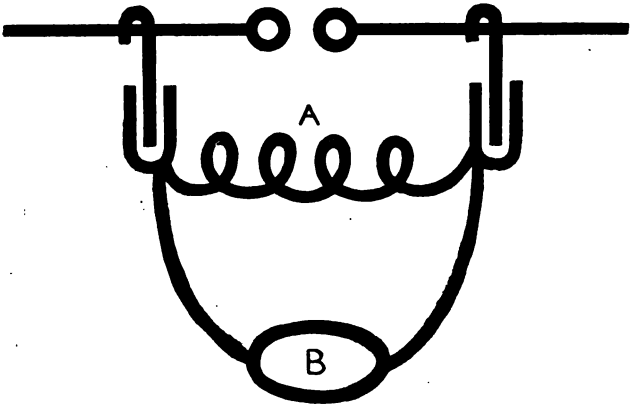

FIG. LV.

vated, and over-treatment may produce a relaxed sensation lasting for many hours. Patients suffering from a weakened nervous system are very sensitive to this treatment, and those suffering from neurasthenia and exophthalmic goitre should not have long treatments with derived currents. Short exposures not lasting for more than five or eight minutes produce buoyancy.

Derived currents, as described above, are very

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similar to what has been described under static induced currents. These two forms of administering static and high frequency electricity to the human body are nearer together than any other known. Even here, however, there is a great difference. The auto-induction in the solenoid increases the power, and, at the same time, increases the rate of vibration, and, as can easily be demonstrated, has much greater constitutional effects. By holding the electrodes a short distance from the body the increased local effects of derivation currents over static induced currents are apparent at a glance.

Not much observation has been made either as to the physiological or therapeutic effects of derived currents, but more with auto-conduction and auto-condensation. There is no question, however, that treatments by derived currents are destined to fill a large place in high frequency therapeutics.

Auto-conduction.—In auto-conduction the patient is so placed within a solenoid, which is made large enough to enclose him, Fig. LVI, that he does not come in contact with it. In one method the top of the large solenoid is connected with the outside or inside coating of one of the condensers, whichever arrangement suits best, that condenser being opposite to the one connected with the charging apparatus, while the corresponding coating of the other condenser is connected to the lower end of the large solenoid. The D'Arsonval solenoid is not needed in this treatment unless the Leyden jars be very small.

A better way of connection is to attach one jar to either the top or bottom turn of the solenoid, and

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the other jar a few turns above or below, according

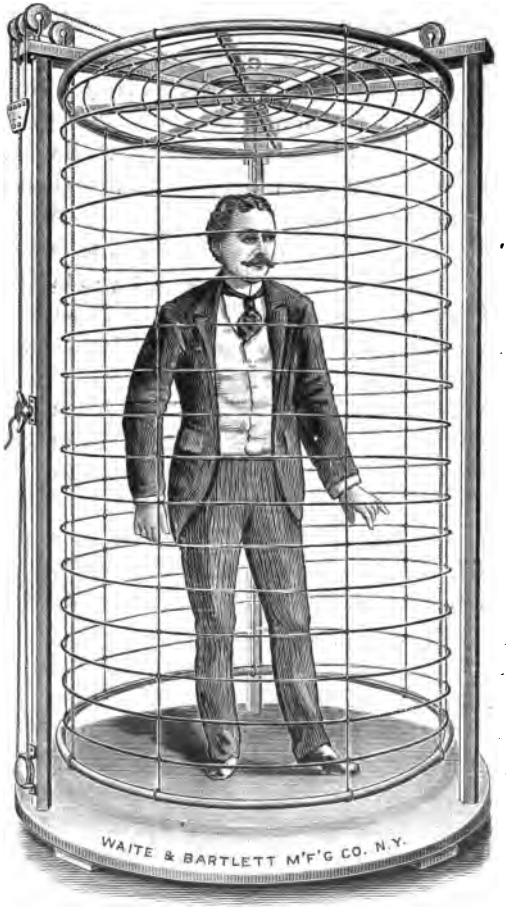

FIG. LVI.

as the top or bottom of the solenoid is to be used.

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This makes a sort of resonator of the solenoid and gives a much stronger inducting effect. It will be well to experiment and discover just what attachment gives the greatest induction effects. This can be easily done by the operator taking a 16-candle power lamp in his hand, grasping one of the terminals in his fingers,—the screw part that fits into the socket,—thus grounding that terminal and pressing the other terminal against one of the rings of the solenoid; the amount of induction can be estimated by the brightness with which the lamp glows. Dr. Piffard has put a top to the large solenoid and connected the center to one jar and the outer one ring to the other.

In auto-conduction the patient is placed within a large electrical field. As the currents surge to and fro through the encompassing solenoid, a large amount of auto-induction takes place. The entire field is saturated with high frequency currents, and the body being a conductor, and in the very center of this field becomes saturated. In proof of this, sparks may be drawn from the patient, or, further, if the patient electrically joins his arms in a circuit by means of the terminals of an electric lamp, it will glow brightly, proving that currents are flowing through him. This treatment may be given for fifteen or twenty minutes, and daily without harm, and when indicated, with great benefit. Many of the physiological and therapeutic effects of high frequency currents have been observed with auto-conduction. Auto-conduction, however, is similar in its action to auto-condensation. A combined method of administration was recommended by Apostoli.

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He attached one of the condensers to the patient direct, and the other to the solenoid. There are other marked manifestations from this method of treatment, but to consider just what occurs would take one into a very wide field of speculation.

Auto-condensation.—By this method of administering high frequency currents, we obtain a very profound action on the body. A couch is constructed,

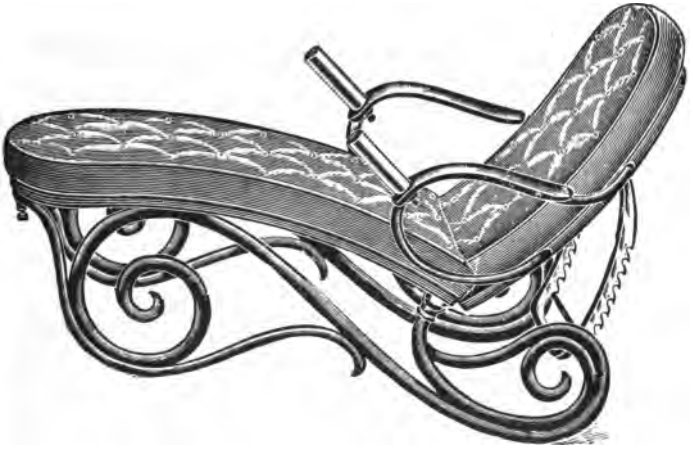

FIG. LVII.

Fig. LVII, with sheets of metal extending the entire length underneath. Above the sheets of metal are large insulating cushions. These cushions should be about two or three inches thick, and made of rubber scraps, so that they produce a thorough insulation. The patient is placed prone on the cushions. A wire leading from one end of the D'Arsonval solenoid is attached to the metal plates

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underneath, and a wire leading from the other end goes direct to the patient. Fig. LVIII represents a schematic drawing of auto-condensation; A, the solenoid; B, the patient; D, metal plate underneath couch; C, the rubber filled cushions. In administering auto-condensation the end of the solenoid connected with the metal plate should be grounded.

A combination of auto-condensation and the local application with glass electrodes attached to the

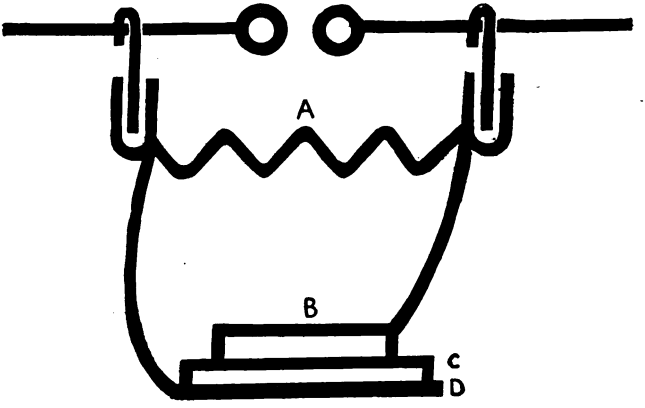

FIG. LVIII.

grounded wire will often be found of great service. Fig. LIX is a schematic representation of the combined treatment: A, the solenoid; B, the patient; D, the metal plate; C, the rubber filled cushions, and E, the glass electrode attached to the grounding wire, and to be applied to any part of the patient.

Piffard has constructed a chair by which one of the terminals of the solenoid is made into a spiral

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and placed in a cushion, as illustrated in Fig. LX. The illustration, however, does not show the connec-

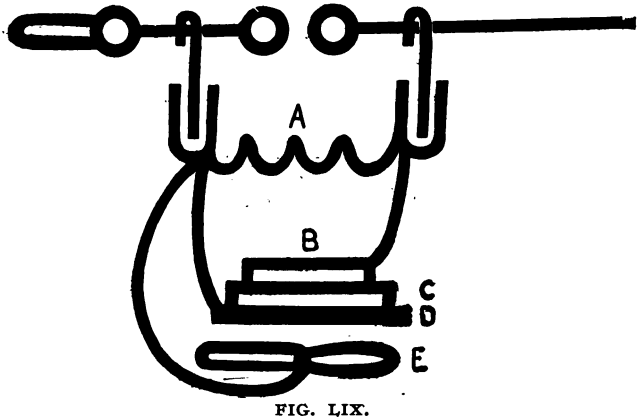

FIG. LIX.

tion of the other end of the selenoid with the patient, which should be the same as in the one above.

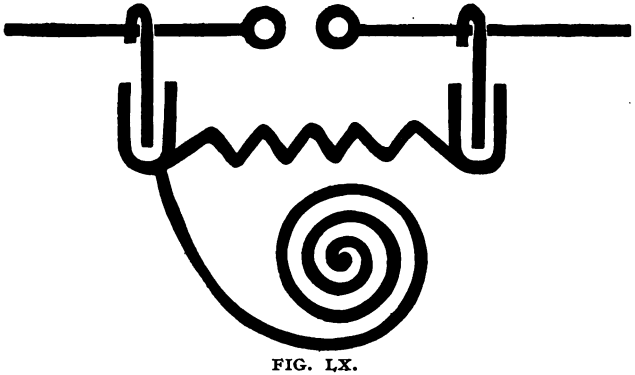

FIG. LX.

It is important that the connection with the patient should be well made. To hold a metal elec-

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trode in one hand is not sufficient. Provision should be made for both hands to be tightly grasped on a metal electrode, and it will be even better if the hands be thoroughly moistened before beginning the treatment. A piece of cheese cloth moistened in a saline solution placed around the metal elec-

FIG. LXI.—PIFFARD CHAIR.

trodes, and the hands firmly grasped over this, is better still, as it ensures good conduction, and a very smooth flow of the current.

The construction of the couch is important. It should be made of dry wood, thoroughly varnished, so as to prevent collection of moisture. It is better to have it fastened together with wooden bolts than

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iron screws. The metal plates underneath the couch should be insulated from the wood, and so distributed as to conduct freely its entire length, thus preventing concentration at any special point or part of the body. With the patient on the couch, and the connections properly made, this is simply a condenser, as the name auto-condensation implies. In other words, the metal plate underneath corresponds to one coating of a Leyden jar, and the body corresponds to the other; the rubber filled cushions acting as the insulator.

When we consider that the body and the metal plates are charged alternately, first, positive, and then negative, millions of times per second from the discharges of the condensers and the solenoid, and still further consider the induction or influence that is taking place between the body and metal plates through the insulating cushions, it is evident that the effects upon the body must be great. Auto-condensation is undoubtedly the most powerful means, and the most effective way of general administration of high frequency currents. It is the method that has been most used in observing the physiological effects of the currents, such as increased blood pressure, increased oxygenation, increased elimination, and, in fact, all the physiological effects produced from a general administration of high frequency currents. It will also be found, that most of the good results from D'Arsonvalzation have been produced by auto-condensation. While derivation and auto-conduction have some special actions of their own, in our present state of knowledge, auto-condensation is undoubtedly the most useful.

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The dose in auto-condensation is important. As a rule, from 200 to 450 m. a. may be given for from five to ten, and in certain conditions, fifteen minutes. There are no conditions in which 150 m. a. may not be given.

In administering auto-condensation the terminals are attached, one to one end of the solenoid, and the other terminal to a sliding connection, Fig. LXII which may be moved along so as to take in as many or as few the turns of the solenoid as needed. If this sliding terminal be placed up close to the end of the solenoid from which the first wire leads, and the current turned on, it will be found that the hot wire milliampere-meter will register but little current. If now the sliding terminal be moved along over the solenoid, as each successive spiral of wire is brought into the circuit, the meter measures more until a limit is reached, when each succeeding spiral reduces the amount of current going through the patient. The current given the patient in auto-condensation may, therefore, be regulated to a nicety.

Local Applications.—We now come to applications of high frequency currents derived either from the resonator, or from the secondary windings of the various Tesla oscillators. Local applications are, as a rule, monopolar. They may be direct, with an electrode placed directly on the skin, or held a very short distance from the body, when a shower of fine sparks pass through the intermediate space, and also by an effleuve.

In administering treatment by the direct method, it should be modified according to the results sought

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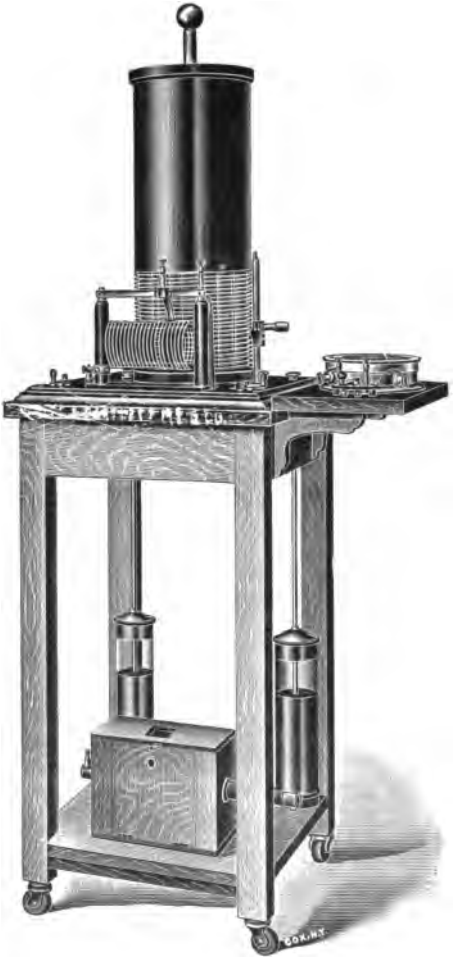

FIG. LXII.—COMBINED D'ARSONVAL, SOLENOID AND OUDIN RESONATOR.

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for. If deep action is desired, the electrode should be held firmly to the skin. On the other hand, if action is most desired on the skin or nerve filaments, and the peripheral circulation, the electrode should be held a short distance away, so as to increase the resistance, this necessitating the accumulation of a larger electro-motive force, which passes from the electrode to the body in a shower of fine sparks, producing a profound action on the entire superficial area. The same action takes place when the electrode is placed over the clothing, as the charge must collect a sufficient electro-motive force to overcome the resistance of the clothes and the intervening space.

Electrodes.—Before proceeding to discuss the local methods of applying high frequency currents to the body, it is necessary first to understand the electrodes used for such applications. These may be divided into three classes, metal, glass vacuum, and glass lined or condenser electrodes. When a piece of metal, such as brass, is attached direct by means of a rheophore to the ball of a resonator, and applied to the skin, a shower of sparks, very irritating, is given off. On account of the disagreeableness of these sparks, the metal electrode is little used. It should have no place in the equipment of a first class high frequency apparatus, and is only used when the disagreeableness of the sparks serves to impress the patient and make up for what may be lacking in the efficiency of the generating apparatus.

The glass lined or condenser electrode is very serviceable for applying high frequency currents to

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the body. It can be made in any shape, and will take the strongest currents without breaking, while the vacuum electrode is very apt to break if the current be increased beyond a medium strength.

The condenser electrode is made of a piece of hollow glass, of the size and shape desired, lined with tinfoil as the inside of the Leyden jar is lined, or, better still, silvered. These electrodes are made to fit into a universal handle, and may be so constructed that the lining is only acted on by induction, that is, there is no direct connection between the lining of the electrode, and the metal part of the handle to which the rheophore is attached; or it may be made so that there is a metallic contact, a copper wire connecting the lining with the brass ending of the handle to which the rheophore is attached. In the latter case the current given off from the electrode is much stronger. When this electrode is brought in contact with the skin a fine shower of sparks passes. This is due to the influence which takes place through the glass, and the consequent neutralization of the influence charges.

Glass vacuum electrodes are more generally used for administering high frequency currents. They do not give off quite as strong a current as the condenser electrode, and treatments with them are consequently better borne; they are made in all shapes and sizes, as the accompanying illustration will show, Fig. LXIII. There are electrodes for all cavities of the body, the nose, throat, urethra, rectum and vagina, as well as different shaped surface electrodes.

It is very important that in the rectal, vaginal and

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throat electrodes there should be an inner chamber in that portion which comes in contact with the more sensitive spots, such as the sphincter or ex-

FIG. LXIII.

ternal organs. A glance at Fig. LXIV will serve to illustrate what is meant by the inner chamber. A,

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represents that part of the electrode which fits into the universal handle. The opposite end B, is that part of the electrode from which the high frequency currents are given off. The space between C has a small tube D, which connects the two chambers A and B. C does not contain a vacuum, but A, B, and D do. The currents generated in the rarified gas in A pass through the smaller tube, D, into B, and induce currents on the outer side of the wall of B. The tissues that come in contact with the middle portion of the electrode, C, are protected from the current. In the condenser electrode the part C is not lined, and the chambers, A and B, are con-

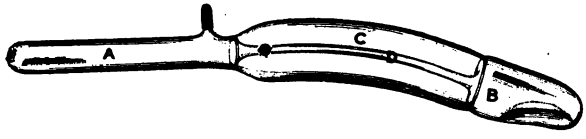

FIG. LXIV.

nected by a copper wire. If electrodes of this construction are not used the sphincter of the rectum and vulva, both of which are very sensitive, will get the larger part of the charge, and but little will be given off higher up where it is needed. When the electrode is introduced, this inner protected part should be opposite the sphincter or the vulva. It is only by using electrodes of this construction that the throat can be properly treated. The vacuum electrode is used in the same way as the condenser, and what has been said regarding that applies equally well to the vacuum electrode.

When treating a very sensitive spot, such as an

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inflamed Schneiderian membrane, the small D'Arsonval solenoid will furnish all the current necessary. If the current should then prove too strong, the operator by placing his hand upon the electrode diverts part of the charge to himself, thus reducing the amount of current which passes to the membrane. In this way the most sensitive part of the body can be treated with high frequency currents without either pain or danger. It is in the local application of high frequency currents with these electrodes that the wondrous effects on the skin and mucous membrane, and the germicidal effects, referred to later on in this chapter, are produced.

When an electrode is brought near a sensitive patient, and the current is turned on, it is better that the operator grasp the electrode tightly, so as to take the full discharge; otherwise when it gets within a distance sufficient for the electro-motive force to overcome the resistance, sparks will pass and may frighten the patient. This is only necessary for the first treatment, until the patient accustoms himself to it.

High Frequency Effleuve.—By attaching to the ball on top of the resonator an electrode, such as is used for administering the static breeze, one with many points being better than one with a single point, a breeze will be given off which simulates in appearance the static breeze. It, however, differs from that in many very important particulars. Only one pole is used, and the breeze is much more severe than even the static brush discharge. Again, it is not necessary to insulate the patient, as with the static application. It is certainly a misnomer to

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call it a breeze at all. It cannot be compared with the brush discharge, and it can never be substituted for the static application. Just what place this method of applying high frequency currents fills in therapeutics is not definitely known as yet, but it undoubtedly will hold an important position when more is known regarding it.

The high frequency output of all the various machines is influenced by the amount of current put into the condensers, and the length of spark which discharges them. Therefore, when a coil is used the greater its electro-motive force the larger the spark it is capable of giving off, and the greater the number of amperes used in the primary circuit the greater the high frequency discharges. It is, therefore, necessary to have a rheostat in the primary circuit, by which the number of amperes used may be regulated. When a static machine is used as the energizing power of the condensers, the amount of charge given them will depend on the size and number of plates of the machine and the speed at which they are made to revolve; it is, therefore, necessary to have a controller on the motor.

The spark-gap can be regulated at will, and it possesses far more importance than is usually accorded it. It should not be enclosed in a glass tube. Its noise is undoubtedly very objectionable, but the perfect working of the machine is more important. It may be enclosed in a wooden box, provided there are holes in the box, and a door that can be opened to allow it to be thoroughly aired. The terminals should be kept smooth by frequent sandpapering. The quality of high frequency currents

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will depend on the clean-cut individuality of the spark at the condensers.

When the resonator is used for energizing electrodes for local treatments, the current can be regulated by a more perfect tuning of the instrument, as described in department of physics.

Physiological Action of High Frequency Currents.—Of the physiological action of high frequency currents on the nervous system, there are many evidences, yet, within certain limits, they make no impression on either motor or sensory nerves. By the method known as auto-condensation the whole system may be so profoundly affected as to modify the general nutrition of the body, increase the arterial tension, increase the elimination of certain constituents of the body, and increase the production of heat; yet, there will be no perceptible action on the nerves. Currents that are estimated to have a potential of several thousand volts, and as high as two amperes, which would be most dangerous if a direct or slowly alternating current were employed, can be borne with impunity. It is a question if these measurements of current strength are entirely accurate, but even granting that they are only comparatively so, it is still a wonder how an individual can endure them. Various reasons have been given to account for this. One explanation is, that the currents are of such short duration that they do not penetrate to the more vital parts. It has been claimed, that inasmuch as this current remains on the surface of metals, it acts only upon the skin when applied to the body. This is not a logical conclusion, as the conditions are very different. The same thing has

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been claimed many times in regard to static electricity, but it is very easy, by the discharge of a static spark, to reach the deepest seated motor point in the body, as evidenced by the vigorous muscular contraction which is produced. On this point from the well known authors Houston and Kennelly may be quoted:

"It has been suggested," say they, "that alternating currents of such high frequency would be unable, in traversing the human body, to penetrate more than a very moderate distance below its surface, and that, therefore, only superficial portions of the body could be directly affected by the discharge. Owing, however, to the feeble electric conductivity of the materials of the body, this skin effect, or tendency of the current to seek the outer layers to the exclusion of the inner layers, is comparatively small at the frequencies which can be practically produced, for, while the depth to which such currents would penetrate in good conductors, such as copper wires, is very small, yet in the case of comparatively high resisting materials, such as those constituting the human body, the penetration would probably extend practically through the entire mass. High frequency alternating currents are, therefore, powerful but painless currents, and are, probably, attended by electrolytic effects in the entire mass, although, as in the case of all alternating currents, little if any accumulation of electrolytic materials can take place."

As we learn more regarding the physiological and therapeutic action of these currents, we may find, that the discharges of very high frequency and small

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amplitude, and those of less frequency and greater amplitude, according to the size of the condenser and resistance of the inductant, each have different effects. It is quite probable that the former acts more upon the integument, while the latter has a deeper seated action.

D'Arsonval's explanation, which is more generally accepted, is, that when the alternating currents become so very high in rate of alternation, as in high frequency discharges, the nerves of the body are incapable of responding to them. An illustration drawn from the optic nerve, which is incapable of responding to vibrations of light when they exceed 800 billions per second, or when they are below 400 billions per second, has been made as a comparison. Freund suggests that it is the low intensity of these currents that cause a lack of sensation, and that in comparison with a faradic apparatus, as the number of interruptions in the primary current is reduced, the intensity of the alternating current in the secondary increase, so here as the frequency of these alternations might be reduced the intensity would be greater, and would therefore produce pain.

No matter if these currents are imperceptible, so far as sensory or motor nerve manifestations are concerned, they do, nevertheless, affect the nervous system. In the first place, there is an increased arterial tension produced. It is quite impossible to do this except by action in some way through the nervous system. This action may be either direct on the vaso-motor nerves, or secondary through the nerve centers. Again, heat in the body is greatly

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increased, being raised to from 80 to 125 calories per hour, and it is not to be supposed that this can be accomplished without the nerve cells in some way being affected. With all this increase in combustion, and the amount of heat the body parts with, the body temperature is raised but very slightly. As a proof of this increase in combustion in the body, a guinea pig when subjected to very prolonged high frequency currents loses weight in a few hours. It is also found that anæsthesia follows the prolonged application of high frequency currents, which, in itself, is proof that the sensory nerves are affected by it.

The elimination of certain excrements of the body is greatly increased by high frequency currents. The elimination of carbonic acid is doubled from 17 to 37 litres, and when an excess of uric acid and urea exists in the system it is reduced to normal, the urea thrown off being increased from 11 to 43 grammes. There is also an increase in the amount of urine excreted. It is these effects, together with the action these currents have of increasing the power of reducing oxyhemoglobin, that makes high frequency currents so useful in chronic rheumatism and gout, especially when there exists besides the uric acid diathesis a state of chronic malnutrition; and they are valuable also in certain forms of kidney diseases.

As another result from moderate application of these currents there is a marked increase in the oxygenation of the blood and a general increase in the nutrition of the body; this latter is probably due to the increased arterial tension, increased heat,

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increased oxygenation, and increased power of imbibition of the tissues. This makes the currents an exceedingly useful remedy for all forms of malnutrition. Most prompt is the action in patients convalescing from depleting and miasmatic diseases. It is claimed by Caffarena that high frequency currents have a direct effect in increasing gastric peristalsis in cases of atony.

We must take into consideration the difference between the simple passage of high frequency currents through the body and the effects produced by the discharge from a condenser or vacuum electrode energized by an Oudin resonator, and held a short distance from the body; in the latter case we get disruptive discharges which produce a profound sensation on the sensory and vaso-motor nerves, and which have the power to increase the arterial and nutritional fluids to whatever part applied. One peculiarity of this local increase of circulation is that the hyperæmia remains a much longer time than when produced by other forms of irritation.

This treatment is especially beneficial for certain nerve pains, such as superficial neuralgia, and for removing the results of inflammatory processes, rearranging the circulation, improving nutrition, and causing absorption of inflammatory products. One of its actions is the building up the nutrition of the skin, and thus curing many of the intractable skin diseases, such as eczema, acne, herpes, leucoderma, and others. It also has a profound reflex action, as well as local. The treatment in certain localities, such as the rectum, will not only cure what hæmorrhoids there may be, but will also remove the consti-

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pation, the cause of which lies far above the section treated. The same is true with diseases of the female organs.

One effect of local applications of high frequency currents results from its bactericidal properties. It is found that its germicidal effects are in proportion to the quantity of the discharge. A one ampere discharge of eight minutes duration failed to hinder the development of bacteria, when a four ampere discharge succeeded. Another thing should be remembered; a disruptive spark discharged from a round ball is far more effective than the same discharge divided into a spray or brush discharge. It cannot be denied that the shower of disruptive discharges from the high frequency electrodes, or the brush discharges of the static, may not be effective if continued long enough. The power of sparks to destroy bacteria is not merely limited to the surface, but it is capable of destroying bacteria after penetrating the human skin, and the depths to which its power may penetrate are not yet known.

The action of the spark discharges, no matter whether it be from a high frequency or static machine, in increasing nutrition and as a bactericide are probably manifold; at least, there may be many factors entering into it. First, the discharge of the spark sets free an enormous amount of ozone, and as this is a powerful antiseptic it exerts its influence to a greater or less depth. This taken with the increased oxygenation of the blood to the part, and the increased heat, may account for a large part, at least, of the germicidal action of the current. It may, however, not account for all of it. There is

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also a slight electrolytic action, together with a certain mechanical effect, which causes an improvement of nutrition, the lessening of the venous stasis, and an increase of the arterial tension. This in itself is a powerful promoter of healing. It is not improbable that certain action on the nerves, either direct or reflex, may play an important part.

D'Arsonval and his students have given the following indications for the employment of high frequency currents:

First, to produce analgesia, this for minor surgical operations, and for superficial neuralgia; the effectiveness of the current for this purpose is, however, very questionable.

Second, diseases which are the effects of tissue changes, diabetes mellitus, gout, chronic rheumatism, obesity.

Third, parasitic diseases, especially tuberculosis.

Fourth, certain diseases of the nervous system.

Fifth, some local diseases of the skin and mucous membrane.

The method of treatment of these diseases belongs to the department of Special Therapeutics.

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CHAPTER X.

ROENTGEN RAY.

Physiological Action of Roentgen Ray.—While there has been considerable experimentation to ascertain the physiological action of the X-ray, and a large amount of information has been gathered, there has been found so much that is contradictory, and, consequently, so many theories have been put forth, that in considering the subject one feels himself floundering in a sea of uncertainty. When a part has been sufficiently irradiated, a reaction takes place, varying from a slight redness to a necrosis of the tissue. This reaction may be due to the cumulative effects of several radiations, or it may be the result of one. One, two, three or four irradiations may not produce any visible effects, while the fifth, sixth or seventh may, and we get a sudden and unexpected reaction apparently from one exposure. There may be changes going on all the while from the first exposure, but imperceptible by any of the methods of detection at present known.

There appears to be a great difference in the amount of irradiation required to produce similar effects in different individuals. Freund's statement that the intensity and time of appearance of the reaction afford a criterion as to the character of the irradiation needs many qualifications. In the first place, the tube must be taken into consideration, and it must be admitted that the eccentricities of

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Crookes' tubes are not to-day at all understood; in the next place, the peculiar idiosyncrasy and susceptibility of the patient must not be overlooked.

It appears, from a careful observation, that the mere passage of the ray through a part does not seem to produce a profound effect on the tissues through which they pass; rather it is the amount of ray absorbed that produces the greatest effect. A ray of but feeble penetrating power, given off from a soft tube, is absorbed mostly in the skin and superficial parts, and as these parts are most susceptible to the action of the ray, reaction is more apt to occur than when a hard tube is used, which gives off more penetrating rays. For the same reason, superficial diseases, such as epithelioma, eczema, lupus and others, are more successfully treated with a soft tube, the rays being absorbed nearer the surface where action is needed.

On the other hand, under deep-seated conditions, where the resistance is great, such as deeply located carcinomas or osteo-sarcomata, the rays from a hard tube will prove more successful, as they penetrate the superficial parts, and are absorbed by the greater resistance underneath. In Roentgen therapeutics the selection of the tube and the quality of the ray is of even more importance than the selection of the dose in medical therapeutics.

The manner in which the ray affects living tissue, is not yet well understood. The theory, first put forward by Tesla, that material particles were projected through the tube into the tissues, has been disproved by abundance of evidence. The main evidence derived from the action of

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X-ray treatment indicates that the ray and the high tension discharges of electricity, which are constantly being given off from the tube and its terminals, together produce the results. Experiments, however, have apparently disclosed most contradictory effects. Whatever part high tension discharges may play in the production of results is not known, or how they may enhance in any particular the action of the X-ray, but certain it is, that when taken away from the X-ray they possess no such properties as has been ascribed to them by some experimenters along this line. Therefore, the principal action must be ascribed to the X-ray in its passage through and absorption by the tissues.

Another question of importance is, on what part, and how, do these rays act. It has been suggested that the changes observed are due to reflex action through the central nervous system stimulated by the local action upon the periphery nerves. This theory, which would explain many things, lacks confirmation by experiments. The general preponderance of opinion is, that the rays act directly upon the cells traversed and absorbed by them, but just how this action takes place is not understood. All sorts of theories have been suggested. An ingenious one is, that a fluorescence is set up in the tissues, and the fluorescent rays produce the action. Another suggestion is, that the ray sets up chemical changes in the tissues, and that the effects are due to these chemical changes, something like an electrolytic process.

Whatever may be the theory of the action of the ray, we know that certain results are attained.

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Practically the first action noticed, after a part has been irradiated, is that the hair falls out, and there appears to be a cutting off of the nutrition to the part. These results, however, are only temporary, for if the irradiation be discontinued at this time, a reaction takes place; nutrition is increased, and the hair returns stronger than before the treatment; therefore, when the ray is used for hypertrichosis, unless the treatment be carried beyond this primary action, the hair will return stronger than before the treatment. The next stage in the process of irradiation is a capillary congestion, with an increase of heat to the part; this is followed by blisters, burns and necrosis, which will be treated under separate headings later in this chapter.

There is no doubt the action of the X-ray is, to a degree, relative. Thousands of cases have been reported where cancer cells have been destroyed, while normal cells in the same field of irradiation have suffered only slight injury, or, perhaps, have not been visibly affected. While cancer cells have great power of proliferation, we know they do not have the power to withstand certain shocks as do healthy cells. This is undoubtedly due to the fact that they have no independent nerve or blood supply. When once they have received a shock, or have been disorganized, they do not have the power to recuperate as would a healthy cell. Their great power of proliferation, however, makes it necessary to keep up the treatment until every cell is destroyed, or there will soon be again produced a very lively colony.

It must be admitted that later experiments as to

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the germicidal properties of the X-ray have been very misleading. From the early reports of cures made in lupus vulgaris, tubercular glands and pulmonary tuberculosis, it was thought that experiments would prove the ray to have great germicidal power. If the experiments have proved anything, they have proved that while the ray may have power over some forms of bacteria, the tubercle bacillus is not one of them. There is a possibility, however, that these experiments have not been carefully made. So certain have been many, from consideration of the clinical results obtained, that the X-ray possessed the greatest germicidal power, especially over the tubercle bacillus, that innumerable theories have been put forward to explain the action, such as the bombardment by the ray, the setting free of ozone, and the production of a local leucocytosis. If further experiments prove that the X-ray does not possess power of destroying the tubercle bacillus, it will show a difference between the actions of the X-ray and the violet ray, which has not hitherto been supposed to exist.

Dr. F. Tilden Brown, of New York, has reported that the X-ray destroys the life of spermatozoa in those who are merely working with it, or come within its influence. It is also suspected that the ray may affect the ovum when administered for diseases which brings the irradiation in that locality. This may account for the ceasing of the hæmorrhages which have been reported following the treatment of hæmorrhagic fibrous tumors.

Roentgen Ray Erythema,—Roentgen Ray Burns,—Roentgen Ray Necrosis.—These three names all have a

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place in this heading. In order to understand more fully the problem of X-ray burns we must study both the gross and the microscopical changes which take place in the tissues by the passage of the X-ray through them. Erythema is intended to apply to that condition where there is a slight inflammation of the cuticle produced by the passage of the X-rays, which does not give much annoyance to the patient, and which ends by a little scaling of the superficial epithelium. The word burns is intended to apply to a more critical condition, when there is actual destruction of the deeper layers of the skin, beginning with a blister and ending in superficial ulceration. The third term, necrosis, is intended to apply to those very serious cases, which fortunately we seldom see, characterized by death in mass not only of the skin, but the tissues underlying it. Necrosis generally comes from long and repeated exposures to the ray given off from a hard tube, and used for some time.

When we come to study these conditions more closely, each may be divided into various stages. When the dermatitis is very slight it is confined principally to the follicle, but it usually spreads over the entire surface. If the process goes no further the inflammation will disappear in a few days. There is not much soreness or other discomfort accompanying this form of dermatitis. The most is a little itching and burning. After a week, or at most ten days, there will be a slight redness of the epidermis, but no permanent mark will be left, except a certain amount of increase of pigment, which will vary with the natural complexion and pigment-forming power of the skin.

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When, however, the destruction goes on to the second stage, blisters and bullæ appear and burst. This leaves at first a red inflamed surface, but in three or four days a grayish membrane appears, which is so closely adherent to the surface that if removed by force, little bleeding points will be left; this will continue from two to five weeks, according to the severity of the burn. It will begin to disappear in patches, and in their place will form islands of granulations, which, as a rule, will spread over the surface until it is entirely healed. Sometimes these burns will heal in four weeks if they have been properly taken care of and kept thoroughly clean. Occasionally, however, there will be a breaking down of patches on the surface, probably due to the lack of nutrition to the part, and to lack of proper care by the patient, and this will prolong the healing to perhaps eight or ten weeks. As a rule, there is considerable discomfort accompanying these burns in way of a severe burning sensation. This seems to vary greatly in different individuals, some not minding it much, while others, apparently, suffer severely. After a burn of this kind the skin will have a peculiar bald appearance, owing to the lack of hair, and it will be found to be a little thinner than normal. The skin will also be slightly more sensitive for six months or a year.

With necrosis, or burns extending to the subcutaneous tissue, we have at the beginning the same process as described above. The process of destruction, however, continues until the deeper underlying tissues have become involved. The ulcer is covered with a leathery necrotic mass with raised

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inflamed edges bordering it, and separating it from the healthy tissues. This leathery dead tissue will persist almost indefinitely if not removed. The condition seems almost malignant, especially where there is a weakened general condition of the patient. Unlike malignant conditions, however, healthy granulations will begin to form at certain points; the inflamed edges subside and the parts finally heal, leaving cicatricial tissue in its place. When the hand is involved to the finger tips there will first appear a redness about the roots of the nails, the quicks separate, turn outward, and become dry and cracked; the nutrition of the nail is interfered with; transverse lines appear as evidence of malnutrition; the nails split longitudinally and become so brittle that they break very easily, and in several cases the nails came off and may not grow again.

In one case which came under the author's observation, where treatment was given for pain in the tibia and a necrotic ulcer was formed, it was found, on examination later, that the bone had materially changed and had become very much harder than normal. An operation on the bone just before the treatment was given had revealed a bone of normal consistency. The constitutional effects of severe X-ray burns are for a time quite marked. They may be ushered in with a chill followed by fever, which may persist for some days, but in the worst case this disappears before healing is complete.

In regard to treatment of X-ray burns, it cannot be said that any specific has been found. In the

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milder forms of dermatitis soothing or astringent lotions may be applied. In cases of the second class, two applications appear to have been most useful, a lanoline ointment, and the stearate of zinc applied in a dry powder; the former while the more acute form of inflammation exists, and the latter to stimulate healing. The most important thing of all is perfect cleanliness, and this is best secured with a weak solution of electrozone or dioxygen. Some of the formaldhyde preparations do very well.

With necrosis more perfect rest and attention to the diet and regimen of the patient is necessary. Surgical procedures may often be necessary. Healing will frequently be facilitated by curetting off the leathery necrosed covering of the ulcer. Skin grafting is often successful, owing to the very poor nutrition of the parts. All the expedients that have been recommended for the treatment of severe burns from other causes may be used, and as they can be found in any text book on surgery it is unnecessary to repeat them here.

In considering the cause of the X-ray burns, the author is aware that there are as many theories regarding these phenomena as there are pages in a book, which in itself is evidence that the profession is still groping in the dark as to their causation and their true pathology. Just why one case should be burned in a single short exposure and another require several exposures to produce an erythema is still a mystery. Why the accumulative action will in some cases go on without apparent effect, until it breaks out into a severe burn, and in others a tanning will take place, which seems to protect the

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part, so that with the severest treatments it will be impossible to produce a burn, no one has yet satisfactorily explained.

There are, however, certain factors which have a bearing upon the production of X-ray burns, and these may be put into two classes, those relating to the tube and the character of the radiations, and those depending on the peculiarities of the patient. The first mentioned we may divide into, first, the distance the tube is from the patient; second, the quality of the tube, and the character and quality of the ray; third, the length of time of exposure, and fourth, an unknown quality, which is also a very large one. There is no doubt that the reaction and consequent burns are more apt to occur with the tube near the body, and, while a case occurs now and then which seems to contradict this statement, it may be put down as a pretty general proposition, that the therapeutic results are also greater when the tube is near the body.

As has been stated, feebly penetrating rays, given off in larger quantity from a soft tube, and absorbed in the skin or cellular tissue, are more apt to produce burns than are the rays from a hard tube, but when a burn does occur from the use of a hard tube, it will be found to be deeper seated and harder to heal; this undoubtedly is due to the fact that the absorption of the rays by the deeper tissues has caused a destruction of tissues at that point. The greater the output of the tube, the more the liability to burn. The greater the potential power energizing the tube, the more the liability to burn. Whether the frequency of interruptions in the pri-

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mary current when a coil is used has any direct bearing on the production of burns is a question. Certain it is, however, that there is a greater liability to burns when a coil is used for energizing the tube than when a static machine is used. This is undoubtedly owing to the greater quantity generated in the coil. With a given quantity, and all other conditions being equal, the reactionary results will be about in proportion to the length of time of exposure, but there is no evidence that this proportion is uniform.

When we come to the last factor, the unknown quantity, there are many conditions entering into it of which we as yet have not the slightest idea. The science is still empirical; we have no way of accurately measuring the amonnt of energy expended within the tube, and very slight cause may change the character of the utilization of this energy, so that the conditions may be entirely different. Just why a tube which has not produced a burn suddenly develops into one that burns everything brought before it, and after being put aside for six months or a year can be used again without the former danger, no one has as yet been able to satisfactorily explain. Contrary to the accepted idea that soft tubes are more apt to burn than hard ones, the tubes that exhibit these peculiarities are always old and hard ones.

When we come to the second classification, the idiosyncrasy of the patient, we are still deeper in the mystery. In one case that came under the author's observation a hand was placed before the fluoroscope for about thirty seconds to test the

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strength of the ray; when, immediately after, without changes in any way, the ray was passed through a shoulder, for twelve minutes, for the purpose of making a skiagraph, the hand was severely burned, while the shoulder did not even show the slightest sign of erythema. Two cases which were burned unexpectedly with slight exposure were syphilitics; one was tubercular, and the other had a carcinoma, but did not exhibit any other struma.

In those cases where a slight erythema, accompanied with tanning, makes its appearance, and continues to gradually increase with each treatment until it fairly breaks out into a burn, there is not much danger unless the operator is careless, or wishes to produce this violent reaction for therapeutic purposes, as the erythema has given him fair warning. But even here the operator must use great judgment, for he may be able to continue the rays with impunity and thereby produce good results therapeutically, while if he discontinues at this point he perhaps loses a golden opportunity of which advantage cannot again be taken. It is, however, those cases which come as a thunderclap from a clear sky that astonish and frighten both doctor and patient. Where there has been an erythema, ever so slight, and when, perhaps, there has been but one or two very short treatments given, and a severe burn appears, that is something which no amount of judgment or knowledge, in the present state of the science, can prevent.

The question of how to avoid X-ray burns can only be answered by giving certain rules, which, if followed, will prevent most burns, but, be it not for-

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gotten, not every one. When a physician undertakes the treatment of a case by X-ray, he should carefully go over with the patient the possibility of burns, and place the responsibility of such an accident on that individual. He should not, though, take this for a license, but should in justice to the patient, and the confidence placed in him, use every precaution known to science to prevent any such calamity.

The precautions to be taken have already been indicated, so far as relates to the distance the tube should be placed from the patient, the kind of tube, the quality of the ray, the quality of current energizing the tube, and the length of exposure. The shielding of exposed parts of the body on which the ray is not needed for therapeutic purposes, and other technicalities, will be considered under the technic of treatment.

In closing the subject, let it be repeated, that, owing to idiosyncrasies of certain individuals, and to many unknown factors, if treatment is rigorously pursued, or even at times when it is not, burns will occur in the most careful hands. Still, this should not lessen the greatest vigilance and care on the part of the operator to avoid them, and in a large proportion of cases he will be successful.

TECHNIC OF TREATMENT WITH ROENTGEN RAY.

Tube Holders.—The tube holder should be strong, and with such a large base that there need be no danger of its tipping over. It should also be made so flexible that the tube can be placed in any position. Various models are on the market, all possessing merit of one kind or another.

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Protecting Shields.—The chief requirement for a shield is that it be impervious to the rays. Shields may be divided into two classes; one in which the shield is placed on the patient, and the other where

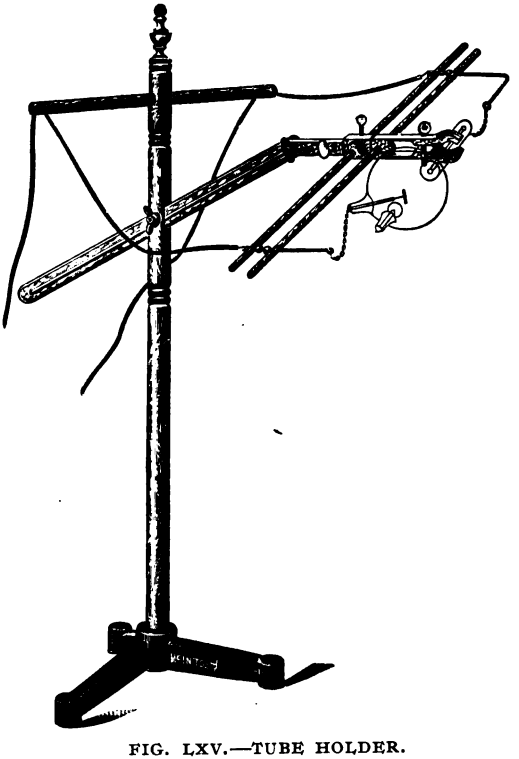

FIG. LXV.—TUBE HOLDER.

it is placed next to the tube. For the former, either thinly rolled tin or lead foil is best. This may be made to fit any part of the body, and is a cheap and efficient protection. The only drawback to it is,

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that when a hard tube is used, and there is considerable induction effect from the terminals, little

FIG. LXVI.—PROTECTING SHIELD PLACED ON A TABLE.

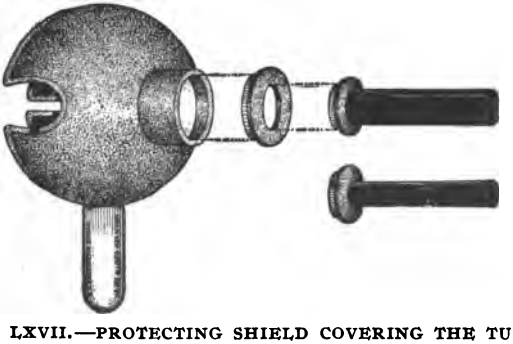

FIG. LXVII.—PROTECTING SHIELD COVERING THE TUBE.

sparks may pass from the shield, and prove very annoying to the patient.

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Shields that are placed next the tube should be made of some material that is a non-conductor of electricity, as well as of X-rays, for if it conducts well, it will short-circuit the current, and consequently take off from the energizing of the tube. The opening through which the ray passes should be capable of varying in size from a small opening, say, three-quarters of an inch in diameter, to five inches. Those that completely cover the tube, except the back, are best, as they protect the operator, who must necessarily be more or less around the tube during treatment, and when he is so exposed for hours a day he is in great danger, even though he does not get directly in the focus of the tube.

A very important thing to decide is the length of time for exposure, that is, the length of each exposure, and the total length of all exposures. One exposure of an hour will produce much greater results in the way of a dermatitis than ten exposures of six minutes each. On the other hand, in using the X-ray for therapeutic purposes, it is the author's opinion that short exposures repeated at regular intervals have a much better effect than long exposures of one or two sittings. Therefore, in these treatments the maximum therapeutic effects and the minimum danger to burns are produced by giving short exposures, from six to twelve minutes, at regular intervals. The number of treatments required for any given diseased condition cannot be told, any more than the number of doses of medicine can be stated, as each individual case will differ. The regular intervals at which the treatments may be

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given may possibly be every day for a short period, but more generally one, two or three times a week. It is well at first to have the intervals infrequent, until the susceptibility of the patient is ascertained.

The next important question is: At what distance shall the tube be placed from the patient? Here there is a great difference of opinion. With the X-ray, as with light, the energy of the radiation varies inversely to the distance of the ray source; therefore, when the tube is placed at half the distance, the ray will have four times the energy on the part exposed. Taking these facts into consideration, it is evident that, where the tube is placed near the patient, great care should be observed. In beginning with a case the tube may be placed ten or twelve inches away. If no particular signs of reaction appear, it may after a few treatments be brought closer, the average distance being about eight inches.

The length of time for exposure is from eight to ten minutes. Taking all cases into consideration, this will be found best suited to most, although there may be some where a longer exposure is needed. This should, however, be governed also by the quality of the ray. When a powerful energy is being given off from a tube it may be better to shorten the period of exposure.

The quality of the ray must be suited to the condition treated. One must depend upon his trained eye to judge by the fluorescence of tube what kind of a ray he is getting, it being yellowish and copious in a soft tube, and greenish in a hard tube. Some depend on the length of spark between the terminals

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of the generating apparatus to determine the quality of the tube. If a tube will fluoresce when the terminals are but two or three inches apart, it shows that the resistance of the tube is very slight, and it is, therefore, very soft. If it is necessary to separate the terminals six or seven inches before the spark between them ceases and the tube begins to fluoresce, the tube is medium, and when it requires a distance of eight, ten or twelve inches before the spark between them ceases and the tube fluoresces, the tube is a very hard one. There are so many things to be taken into consideration that this method of gauging a tube is very difficult.

The best method of testing a tube is to gauge the penetrability of the ray; there is nothing better for this purpose than the hand. The degree of penetrability of the flesh, the sharpness of outlines of the bones in contrast with the flesh, and last, the degree of penetrability of the bones, they showing very dark on the screen with a soft tube and very light with a hard tube, all tend to make the hand the best of skiameters. Nothing, however, is more dangerous to the operator than this method of testing and most of the risks due to operating result therefrom.

To obviate the necessity of using the hand for this purpose the author has devised a simple skiameter, illustrated in Fig. LXVIII. The shield on the handle is for the protection of the operator's hand. The skiameter proper is a square piece of aluminum two inches in diameter, on which are placed four squares of aluminum, copper, tin and lead. In the special therapeutics of this volume, when a soft

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tube is mentioned, it is one that will show a sharp outline of the steel rod on square number one; medium soft, the outline clear on square number two; medium, the outline clear on square number three, and hard, the outline clear on square number four. The comparative gradations of opacity of these metals to the ray furnish a very good idea of its penetrability. The steel rod, seen at the left,

FIG. LXVIII.

can, by a little device on the handle, be swept across the surface of the meter and furnishes a better comparison than can be secured by the squares alone. A very weak ray will penetrate number one, or the aluminum, while it requires a very powerful ray to give a clean-cut showing of the steel rod on number four, or the lead square, the intermediate ones, the copper and tin, being gauged by two and three.

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Whether the number of interruptions of the primary current per second when a coil is used has a direct bearing on the therapeutic value of the ray requires still further experimentation to establish. The therapeutic quality of the ray undoubtedly varies with the quality of the energy put through the tube, and as the science advances the applications will be gauged by the capacity of the coil, the relative proportion of the primary and secondary coils, the amperage and voltage of the primary current, and the frequency of its interruptions; but these factors are as yet speculative. In America, where the largest amount of therapeutic work has been done with the X-ray, and where some of the best results have been obtained, the static machine, which is wonderfully varying in its capacity, has been very largely employed for energizing the tube.

The direction of the ray upon the part is of importance. Its greatest effects are when it strikes at right angles to the part. In irradiating the chin for hypertrichosis, if the tube be placed so that the ray goes direct to the point of the chin, the hairs will all fall off on the point, while just underneath, even though it be but a fraction of an inch further from the tube the hairs are not affected. That the rays given off at an oblique angle of the tube, or more at right angles to the anticathode, have better effects in some cases, or have any different effect than they have at right angles to the tube, has not been borne out in the author's experience.

Exposed parts, such as the hands, face and neck, are more susceptible to burning than other parts of the body, and should, therefore, be carefully pro-

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tected when they are not the parts to be treated, and when the tube is in such a position that they get the rays. In treating tubercular patches, or the many forms of skin diseases, or in hypertrichosis, all other parts should be so protected that the ray should be limited to the space to be treated. In cancerous conditions the author believes there is great danger of limiting the ray too much. In treating a carcinoma of the breast, both glands should be radiated so as to prevent the reappearance of the disease in the healthy one. The strongest point of focus of the ray should be placed over the carcinoma, but the rays at an angle should not be prevented from falling on the healthy gland. The same rule applies to epithelioma where the neighboring glands are liable to become involved, and with sarcoma a very wide region should be irradiated.

Each operator, after some experience, will learn methods of procedure, and a technic, peculiar to himself. It is a matter of judgment in which rules help to form that judgment, as well as build up a broader technic, and the more expert one becomes in this technic, the better will be the results that he achieves.

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CHAPTER XI.

VIOLET RAY—FINSEN RAY—ACTINIC RAY.

The Physiological Action of Light.—Probably no therapeutic measure that has come to us from abroad has been so little understood, and at the same time so misused, as Dr. Finsen's methods. Its range of usefulness is very limited but, within that range it can, at present, be supplanted by no other known therapeutic agent. In order, however, for it to fulfill these high ideals it should be given with an exact technic. In no place in therapeutics is this more essential. It is called the violet light treatment, because it was supposed that the violet part of the spectrum was alone necessary. This was, however, found to be a mistake, all the colors of the spectrum being required. It is called the Finsen light treatment, because Dr. Niles R. Finsen, of Copenhagen, first formulated the technic necessary to its success, and it was called the actinic treatment, because the supposed effective rays possessed great actinic quality.

The effect of light on animal and plant life, and its varied effects on the human economy, constitute so broad a subject that volumes might be written on it. As this little book is intended to be very practical, only those things which will enlighten us as to the therapeutic value of the light in its limited field will be considered here.

When we study the physiological effects of light

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upon the human body, we find much that is useful to us as therapeutists. The rays from the two ends of the spectrum differ greatly in physiological action. If the bare skin, on a portion of the body that has been protected by clothing, be exposed to the sun's rays for some time, what is known as a burn takes place. Although this is not what is ordinarily known as a burn. If the chemical rays at the violet end of the spectrum be filtered out very little burning takes place; yet, all the heat rays are permitted to impinge upon the skin. Furthermore, in the case of a burn from heat, the burning sensation and inflammation takes place at once, while with the sun burn they begin some hours after. It is, therefore, evident that it is the action of the chemical rays upon the skin which produce this result.

When a sun burn heals there is an increase of pigment in the skin, commonly known as tan. This pigment, which is also produced by the chemical rays, acts as a protection against the deleterious effects of these rays, and is, therefore, useful to prevent further deleterious effects. Finsen proved this by painting a ring around his arm with black paint, afterward exposing his arm to the sun's rays for three hours, and immediately after removing the paint. The protected ring was not affected by the sun's rays, while the entire remainder of the arm was. After the erythema had disappeared, leaving a pigmentive staining, he again exposed the same arm, when the ring was violently attacked with erythema a few hours after, but the pigmented surface was not affected. It is a provision of nature

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that this pigment is brought to the surface and the skin protected on exposed surfaces, so that the stimulating effects of light may be enjoyed by all living creatures, without the deleterious effects of the chemical rays. The dark color of the skin of people living in southern climates is due to this action of the chemical rays upon the skin, which takes many generations to perfect.

Recognizing that it was the chemical rays that produce the deleterious effects upon the skin, Finsen thought that if a patient suffering from small-pox could be protected from these rays suppuration would not take place and thus scars would be avoided. Finsen was not the first to propose this, as at least two men had suggested it before him. To him, however, is due the credit of carrying out the theory to its logical conclusion, and causing it to be put to a practical test. In studying the subject he was strengthened in his belief by finding that scores of methods recommended by different men were of such a nature as to protect the skin from light, and that these methods were most successful. His method was to enclose the patient in a room from which all light was excluded, except what might filter in through red glass, or through red curtains, which filtered out all the chemical or violet rays.

If the chemical rays are filtered out and allowed to come in contact with the skin alone we do not get the same degree of deleterious effects as when the whole shaft of light is used. This, however, is not because the red and contiguous rays play any important part in producing the bad effects in them-

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selves, but that by their greater force, and their consequent greater power of penetration, they carry the chemical rays in with them, so that the chemical rays have a very much deeper action. This proves the necessity of using all the rays of the spectrum in treating diseases of the skin, when we wish a penetration of the violet or germicidal ray. It should be understood that the red and contiguous rays do not carry the violet and ultra-violet rays with them as far as they penetrate, but only to a degree, for different constituents of the body absorb different parts of the spectrum, and it is this absorption of the ultra-violet rays which has most to do with its action. The penetration of the ray is in direct proportion to its power, and, therefore, the necessity of using the most powerful light attainable.

It has long been known that white light is a great life-producing power in both the animal and the vegetable kingdom. This is proved by the increase in the growth of hair under the stimulation of the light. The hair on the hands, and other exposed parts, grows rapidly whenever the light is allowed to shine on them, as is shown by the increase in the hair on the fingers of the nurses who administer the light treatment in the Finsen Institute. It is this power to stimulate the growth of hair that makes this treatment so successful in alopecia areata. It is at the same time a most powerful germicide. In this respect it might be compared with oxygen, which is the most essential element in the animal and vegetable kingdom, and is at the same time the most destructive of bacteria of all kinds. It may be finally proven that the life-giving power of both light

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and oxygen is due to their bactericidal properties in destroying a multiplicity of germs of which we know nothing as yet, and, when not thus dislodged, sap the vitality of the plant or animal.

As previously stated, the part of the light which possesses this bactericidal action is the chemical rays, but the other rays are just as essential, as they penetrate sufficiently deep and carry the bactericidal rays along with them to destroy germs imbedded in the tissues.

The great penetrability of the rays from the red and contiguous end of the spectrum is proved by their power to illuminate the face when an incandescent lamp is placed in the mouth; or when a shaft of white light is passed through the hand in a darkened room. If the rays from the red end of the spectrum be cut out, leaving only the violet, no illumination takes place.

Just how the chemical rays possess bactericidal action is to-day largely a matter of speculation. It is, however, known that they both destroy the food on which the bacteria feed, and also have a direct destructive action on the bacteria itself. As the presence of oxygen is necessary for this action it has been thought that light set free oxygen which produced the bactericidal action. There are, however, many points against this theory.

The bactericidal properties of light increase with the power of light, and also with the concentration. Indeed, it is only by concentration of light upon certain bacteria that they can be destroyed. This is true of the tubercle bacillus. If sunlight, which in reality possesses the largest amount of chemical

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rays, and, consequently, the greatest power to destroy the tubercle bacillus, would destroy them by simply shining upon the part affected, there would be no such thing as lupus vulgaris on exposed parts of the body; while, in reality, a very large proportion of the cases of lupus vulgaris are found on the face, which is constantly exposed to sunlight. It is, therefore, only by powerful concentration that light becomes efficient as a germicide. Finsen claims that the power of concentrated light to kill bacteria is fifteen times greater than unconcentrated light.

Treatments.—In giving treatments with light, one of the essential things is the exclusion of the blood from the part treated. Finsen thought the opposite at first. He argued that the presence of oxygen was necessary for the bactericidal action of the ray, but soon discovered that in this he was mistaken. He experimented by placing a film of photographic paper on one side of the ear, and allowed a shaft of light to impinge upon the other. At the end of five minutes no action had taken place on the film. When, however, pressure was made on the part, so as to exclude the blood and cause the part to become exsanguine, the film was thoroughly blackened in twenty seconds. This is owing to the absorption power of the blood, which, in those treatments when it is desired to have the ray penetrate at all deeply, should be excluded by force.

After proper focusing of the light the most important thing is the management of the compressor for the purpose of causing the part to become exsanguine. This is done by the use of compressors. These compressors are made of quartz, two lenses

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being used separated by about one-half inch, so that water may be circulated between them, and thus filter out what little heat rays have passed through the tube. These compressors are made of different sizes, and also differ in construction to fit the various surfaces and cavities of the body, such as the cheek, forehead, mouth and nose. When giving treatment these compressors are held in position by a nurse, or whoever gives the treatment, and who, at the same time, keeps the focus of the light directed upon the part treated. Dr. Piffard has recommended the injection cataphorically of adrenalin, which by its power to contract the capillaries removes the blood from the part, but so far as the author knows, this has never been carried to practical results. A very essential thing in treating lupus vulgaris, epithelioma, or any other disease where there is a discharge which may cover the surface, is first to remove all the discharge, as it obstructs the passage of the ray to the deeper parts. This is best done by applying a weak solution of dioxygen. The method of procedure in giving a treatment is as follows:

After cleansing the part, if this be necessary, the compressor is applied and sufficient pressure made to cause the immediate part to become exsanguine. Treatment may last from fifteen to seventy minutes. The variation in time of treatment depends upon the disease treated, although the susceptibility of the patient, and the amount of the reaction, should also be considered. With pigmentary naevi shorter treatments may be employed, while with lupus vulgaris one hour, or even an hour and a quarter,

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should be given. One of the most common causes of failure in light therapy has been the great desire to shorten the treatment, and this has been the cause of the invention of many of the lamps to-day on the market. When it is found that it requires only two or three, or even fifteen minutes to kill germs exposed to the light, it is argued that an hour's exposure is not imperative, but Freund's experience has demonstrated that the long exposure is necessary for success.

It should be remembered that the bacteria examined after these short exposures have not been the deepest in the tissues, and that they have been removed soon after the exposure. Now, it is just possible that, had these germs been allowed to remain in congenial surroundings, kept to a correct temperature by the heat of the body, and bathed in nourishing fluids, they might have revived, or, in other words, they were not so thoroughly destroyed but that they might have again become active, while the longer treatment more effectively destroys them. Furthermore, the mononeuclear round cells, which lie very deep and are the most resistant of all the lupus cells, have still been found to be active after long and repeated exposures.

It will be noticed, in about twelve hours after the treatment, that the part will be irritated and become puffy, occasionally œdematous. This, however, gradually passes away. Sometimes the patient will be in a condition that another treatment may be given to the same part in three days; in others a lapse of a week may be required. The reactions differ greatly under different conditions and in differ-

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ent individuals, both as to the time at which it makes its appearance and the length of time it continues. The author has seen a very bad case of lupus vulgaris cured when there was at no time any marked reaction. This contradicts the theory some have put forth that it is the inflammatory reaction which produces the germicidal effect and produces the cure. Unquestionably it is the light itself.

The diseases treated in the Finsen Institute at Copenhagen are acne, eczema, epithelioma, lupus erythematosus, lupus vulgaris, alopecia areata, and pigmentary deposits. Some minor forms of skin diseases are also treated successfully, and still others as an experiment. At present experiments are being tried by applying erosine and other fluorescent substances directly to the affected part. These give off rays of fluorescence when ultra-violet light comes in contact with them. So far the experiments have proved unsuccessful.

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CHAPTER XII.

ELECTRIC LIGHT HEAT BATH.

There has been much misunderstanding on the part of the profession regarding the electric light bath, as it is at present on the market.

The bath invented by Dr. Kellogg, of Battle Creek, as used to-day, is simply a closed cabinet lined with asbestos, which, being a non-conductor, retains all the heat given off from the lamps, and, at the same time, preserves the woodwork of which the bath is constructed. In this cabinet are placed many electric incandescent lamps, generally of sixteen candle power. These may be placed in rows around the entire bath, or in places to correspond with certain regions of the body. The most complete cabinet is arranged so that by turning switches, lamps may be lighted in different parts of the cabinet, or all may be utilized if necessary. In this cabinet the patient is seated on a stool, and the cabinet closed around the neck, leaving the head in the free air.

It should be understood that this is simply a heat bath, or more properly described as a dry heat bath, and it is not a light bath in the same sense described by Dr. Finsen. His object was to bathe the patient in the light rays, especially including the chemical rays, and utilizing the other rays of the spectrum to help to drive the chemical rays into the tissues.

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With the Kellogg bath the chemical rays are mostly filtered out, as the original light is within the glass

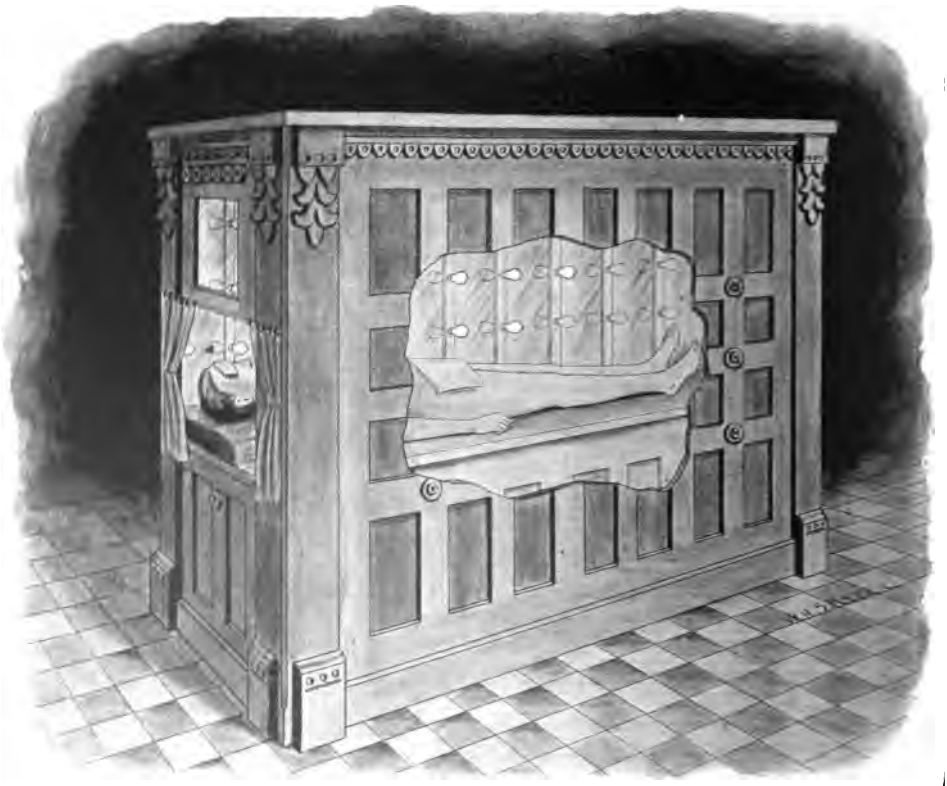

FIG. LXIX.—HORIZONTAL BATH AS MANUFACTURED FOR DR. KELLOGG BY THE ELECTRICAL LIGHT BATH COMPANY.

bulbs, and glass admits the passage of but few chemical rays. On the other hand, rays from the

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FIG. LXX.—UPRIGHT BATH.

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other end of the spectrum, such as the heat rays, pass freely through the glass, and those that are absorbed by the glass are reconverted into heat and given off from the bulb.

When we consider the closeness of the cabinet, it will be seen that the patient simply gets a heat bath. This heat has different properties from the ordinary hot water bath. There are, undoubtedly, some specific properties in the light waves that come through the bulbs, but what these are it is difficult at present to say. There are certain effects from the heat here produced, such as drawing the blood to the surface of the body, flushing the capillaries, opening the pores of the skin, and thus relieving the pressure on the internal organs, and, at the same time, through the profuse perspiration, eliminating many excrements, such as urea, and uric acid in gout and chronic rheumatic affections.

So well known is the effect of heat when applied in such a general way that there is no call to go more into detail here. The electric light heat bath is an excellent means of producing this end, and it is especially good in certain forms of Bright's disease to assist in the elimination of the urea. It may be used for the reduction of certain arthritic inflammations. For this purpose some baths have been made to treat the joints separately. It has also been recommended for a few of the interstitial skin diseases, but so far as reliable data is concerned, its usefulness has been mostly limited to the above mentioned conditions.

In administering the bath judgment should be exercised, especially when the entire body is enclosed

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in the cabinet, and at the sign of faintness the heat should be lowered, or the bath should be discontinued. It is best to begin with a four or five minutes' bath, and a temperature of not more than 150 degrees Fahr. This may be increased to a ten minutes' bath, and the temperature may be raised to 200 degrees Fahr.

It should be borne in mind, that much powerful sweating lowers the vitality of the body, and there is danger of chilling the patient when he goes out into the cold air immediately after, For this reason these baths are best suited to sanitaria and hospitals, where the patient can lie down in a comfortable room for a long time after, which helps to prolong the effects of the bath, and also prevents dangerous complications that may arise from chilling. When the bath is local, as when one of the joints is treated, it may be prolonged even to thirty minutes, and the temperature may be raised to 250 degrees Fahr. There is not the same danger of chills following the local treatment, but the possibility must never be forgotten.

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CHAPTER XIII.

ELECTRIC LIGHT LIGHT BATH.

This bath is arranged with two objects in view. First, the heat rays are filtered out, and it is, therefore, in no sense a heat bath; and, second, the chemical rays are applied to all surfaces of the body. In an ordinary bath tub is placed at an angle at the curve where the sides meet the bottom long strips of mirror glass, which are so constructed that the amalgam on the back is protected from action of the water. These mirrors are for the purpose of reflecting the rays of light on the sides and back of the patient, as he lies stretched out on an open wicker couch in the tub. Over the top of the tub are suspended horizontally two twenty thousand candle power arc lamps, covered by reflectors, so as to direct all the rays of the lamps into the tub. The lamps with their reflectors are so constructed that they can be swung back for the patient to enter or get out of the bath. The idea of this bath is to give the patient the stimulation of a cool bath, and, at the same time, the stimulating effects of the light ray.

The tub is about half filled with water and the patient immersed in it. The temperature of the water is all important. Of course, it must vary according to the temperament and physical condition of the patient. In a general way, it may be said, one can begin with 94 degrees, and gradually de-

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crease to 84 degrees; each patient, however, must be studied individually as to this point. It is important that the water be very clear so as to conduct the rays of light, and if it should be clouded with dirt a filter should be used. The patient is immersed in the water, the lights swung into position over the top of the tub, and the electricity turned on. The water absorbs the heat rays, while the chemical rays reach the body. Naturally the water will become slightly warmer, but this need not be taken seriously into account, as the accumulated warmth is slight for the space of time the bath occupies, and this slight warmth permits the prolongation of the bath to twelve or fifteen minutes, while if it were otherwise, eight or ten minutes would be all that could be borne by the majority of patients. The patient should be thoroughly rubbed with dry crash towels when removed from the bath and allowed to rest for a few minutes, when some exercise or slight massage may be given. The author has never had such a complete bath as this, which, so far as he knows, is entirely original, he never having seen one described, although he has used poor substitutes for it.

These baths possess wonderful tonic qualities; it is not only an excellent treatment for neurasthenia, but it acts admirably on those who suffer from poor circulation, and are constantly in fear of taking cold. It brings the blood to the surface of the body without reducing the system, as does the heat bath, and each bath is a tonic. It also acts well in those cases for which Nauheim baths are given.

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CHAPTER XIV.

RADIUM.

Physiological Action. — It is well established that radium rays are capable of destroying animal tissue. Becquerel carried in his pocket a sealed tube containing radium, and two weeks after the skin beneath the pocket became inflamed and finally dropped out, leaving a very painful ulcer, which required seven weeks to heal. In some cases there has been peeling of the skin and fissures after exposure to the radium rays. Others have noted a hard scab forming on the part that has been exposed to the rays. These different effects are undoubtedly different degrees of the same process, the radium varying in radiating strength, and the length of time of exposure to the rays varying as well. Whenever there is any decisive action on the skin hairs never return after the healing.

A more complete study of the action of these rays on the skin reveal that the blood-vessels are first and more severely attacked than other tissue.

While there is abundant evidence of the power of these rays to destroy living tissue, the exact nature of this destructive action has not been closely studied, but it is probably similar to the X-ray.

Just what effect radium radiations may have on sensory or motor nerves we do not at present know. It has, however, produced paralysis and death in guinea-pigs when placed on the back of the neck,

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showing that the nerve centres are affected by it. It also has a very marked effect on the organs of sight. If a tube of radium, which is wrapped in a few layers of soft paper, be placed over the closed lids in a dark room, flashes of light appear before the eyes. The same effect, but less marked, can be produced by placing the tube on the temples. This effect is supposed to be due to the action of the radiation on the fluids of the eye and retina. In a case that the author treated for atrophy of the optic nerve, the left nerve being in an inflammatory stage, and the right in an atrophied stage, the latter was benefited but not cured, while the former, or the one more recently affected was not improved at all.

It has been suggested that radium placed over the closed lid could be used as a test to discover the condition of the retina before operating for cataract. According to this suggestion if flashes of light appear before the eye the retina is still capable of receiving impressions, and an operation may restore sight, while, if there are no flashes, the retina is no longer capable of receiving impressions, and an operation will be of no avail. Caution should be exercised in experimenting upon the eye, as blindness may be produced.

More marked are the effects of radium upon some of the lower animals, as shown by experiments performed by M. Danysz in the Pasteur Institute of Paris. On February 3d, 1903, he placed in two separate compartments three or four dozen of the larvæ of *Ephestia kuehniella*. In each compartment sufficient flour for food was placed to keep them perfectly nourished for a number of weeks.

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In one of the compartments, which he used as a control flask, nothing out of the ordinary was done. In the other compartment some radium was placed for a few hours, giving the larvæ a bath in the radiations from it. After several weeks it was noticed that the larvæ in the compartment where no radium had been placed had gone through their usual metamorphosis and had changed into moths, which, in their turn, had laid and hatched eggs which had also produced moths, showing that they were in every way normal. In the flask where they had been exposed to the radium it was supposed at first that all had died, but, on closer examination, it was found that those which had been buried deeper in the flour, and thus, to a degree, escaped from the radium ray, were still alive, but not as moths; they had remained in the same condition as when placed in the flask, showing that the protection that they had received resisted the destructive action of the ray, which had not completely destroyed life, but had retarded development.

The germicidal properties of the radium ray are not as yet clearly defined, but it certainly has germicidal effects. Five ccm. of a poisonous solution of streptococcus was injected under each ear of a rabbit. One ear was subjected to the action of uranium rays—the strength of the ray and length of time not given—while the other was left without interference. No inflammation occurred in the irradiated ear, while the other took its natural course.

Freund tried the radiations from different specimens enclosed in paper and aluminum on various cultures placed on plates, and the results were nega-

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tive in each trial. It is possible that Freund's specimens were very poor in radiations.

Aschkinass and Capsari made some experiments which seem to prove that when radium was placed in a receptacle that prevented the easily absorbed rays from escaping, there were no bactericidal properties of the rays, but when placed so that there was nothing to prevent all the rays and emanations coming in contact with the culture, bacteria were at once dislodged.

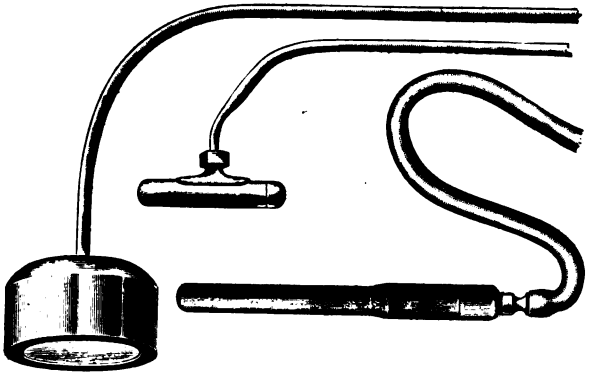

FIG. LXXI.—RADIUM ALUMINUM CONTAINER.

These experiments would appear to prove that if we wish to use radium as a bactericidal remedy, it cannot be enclosed even in aluminum. These investigations did not prove whether it was the alpha rays, or the emanations, both of which latter are capable of coming through a hermetically sealed aluminum tube, that possessed the bactericidal property. To know this would be interesting, as a very small opening would allow the escape of the emanations, while it would not the alpha rays.

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The emanations and alpha rays have lately been brought into use for therapeutic purposes by dissolving the radium in some solvent and applying it by means of coated needles. Mr. Hugo Lieber has given this subject a thorough study, and the quotation given below is taken from a paper read by him before The Society for Experimental Biology and Medicine:

"Radium coatings are made in the following manner: Radium is dissolved in a proper solvent and into this proper solvent a proper material is dipped. This material is then withdrawn, with radium solution adhering to it. The solvent quickly evaporates, leaving the material covered with an exceedingly thin film of radium. The kind of solvent to be used is determined by the nature of the material to be coated. Such solvents are employed as have a tendency to soften and permeate the material which is to be coated. Thus, if *celluloid* rods, discs, or similar instruments are to receive a radium coating in order to be used for the treatment of a certain disease, solvents, such as alcohol, amyl acetate, etc., may be employed. These solvents have a tendency to soften celluloid temporarily. When the solvent evaporates the radium has been uniformly distributed over the celluloid, and also has been incorporated on its surface. In order to prevent accidental removal of the radium in such coatings, the celluloid instruments produced in this way are dipped in a proper collodion solution and are promptly removed from the same. In this process the whole radium coating is covered with a very thin film of collodion. In the course of a few days this

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film of collodion becomes so tough that it will strongly resist destruction, even when considerable force is used, thus affording ample protection for the underlying radium. This thin film, however, permits the alpha rays as well as the emanations to penetrate freely.

"In the preparation of these coatings both the radium and collodion solutions are colored with anilin dye. This is done to show the part that has been coated. Besides, if the radium happens to be removed by accident or otherwise, as by scraping, etc., the disappearance of the color makes such removal evident."

If the emanations and alpha rays are capable of destroying the tubercle bacillus, it would seem that if an apparatus could be so constructed that these emanations could be inhaled we might expect much. Such an apparatus has been constructed by Mr. Lieber. It is illustrated in Fig. LXXII.

"The apparatus consists of a celluloid tube, A, with complete coat of radium on the inside and a collodion covering on the radium coating. By means of a tightly fitting rubber stopper, B, a small glass tube, C, is inserted, which at its end has a large perforated blub in order to produce a uniform air current throughout all parts of the tube. This glass tube, C, has a glass stop-cock, D, and connected with the latter is a rubber bulb, E. By means of another rubber stopper, F, a glass tube, G, with a glass stop-cock, H, is inserted into the other end of the tube. With the loose end of the last glass tube, G, any desirable apparatus may be connected by means of a narrow rubber tube, etc. If we close the two

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glass stop-cocks and allow them to remain closed for several hours a considerable quantity of emanations will collect within the glass tube. If we now blow up the rubber bulb, E, and slowly open the exit stop-cock, H, and then slowly open the entrance stop-cock, D, the compressed air will enter the

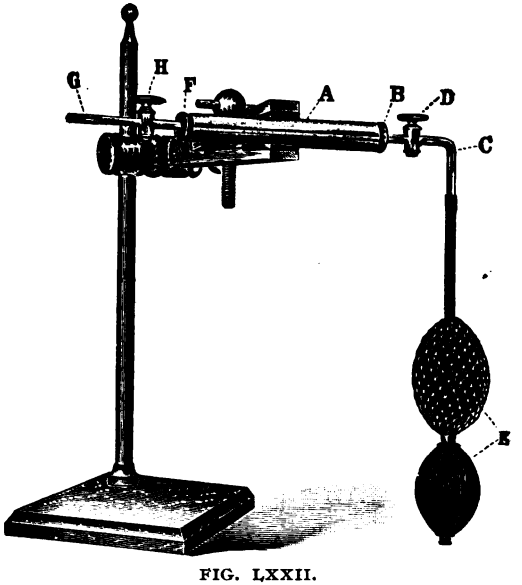

FIG. LXXII.

coated celluloid tube, A, the emanations which will have collected within the celluloid tube will follow the course of the air current, and on inhaling this air the patient will receive the full charge of radium emanations in his lungs. A cancer of the throat or of any part of the body may be treated by the application of a proper radium rod directly, and, be-

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side that, by blowing the emanations, if necessary, directly into the seat of a cancer through a finely pointed hollow exit rod. It is a well-established fact that these emanations are readily deposited upon surfaces with which they come in contact, especially moist surfaces. If, therefore, we permit these emanations to slowly pass into or upon a diseased tissue they will doubtless adhere to a considerable extent to the tissue treated in this way, especially if the applications are made under proper plasters, coverings, coatings, etc., to prevent the ready escape of the gaseous emanations. During their retention in this way the emanations disintegrate, as was stated above.

"A very great advantage of these radium coatings is that all instruments, etc., coated by the method described, can be readily sterilized without loss of radium, for the protective coat effectually resists even continued boiling."

The radiations from radium have also chemical effects; this is shown by its turning ordinary phosphorus into red phosphorus. It also changes glass into a brownish color, and sets free ozone in very appreciable quantities. These various properties of radium led physicians to believe and expect that with it various forms of malignant disease could be successfully combated. It must be admitted, however, that results so far have not borne out the expectation that was at first created, and that radium to-day enjoys no great reputation in the cure of cancer. This, however, should not be set down as a final conclusion as to the efficacy of radium, for when we consider the very small amount that is to

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be had, and the very poor quality of most of it, the only wonder is that it has held its own as well as it has. Some results that the author has seen lately with radium of the one-millionth, even in minute quantity, leads him to believe that with a larger quantity, or even a better quality, there is great hopes for it in some of these conditions.

In using radium for treatments it should be applied as closely to the part as possible. The length of exposure cannot be given with even a degree of accuracy, as there seem to be no two specimens exactly alike in power. If it is found that the absorbable rays, or the emanations, have the greatest curative power, then the aluminum capsule, so universally used now, must be replaced by some other method of retaining the radium. The aluminum capsule is very convenient, as a heavy silver covering can be screwed on over it when not in use, thereby so preventing the escape of rays that it can be carried about without fear of bad results, and the long silver handle, on which it can be fastened, makes it convenient of application to any part.

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CHAPTER XV.

PERMEATING ELECTRICITY.

E. K. Mueller, of Zurich, has instituted an electromagnetic treatment to which he gives the above name. The apparatus consists of a core of some paramagnetic material, preferably soft iron, which is covered with about 200 windings of wire. These windings are traversed by a current of large intensity, 20 to 60 amperes, of comparative low tension and frequency. That the instrument may be kept cool when conducting such a large quantity of electricity the core is made hollow for the circulation of cold water. The current traversing the coils should be alternating, or, if continuous, it should be interrupted or undulating, so as to produce self-induction in the coil. This self magneto-induction, which is very great, produces an undulating magnetic field in its immediate neighborhood, and it is in this field that the patient is placed. It is claimed that the physiological effects of this magnetic field are opposite to those of the D'Arsonval current, in that it acts chiefly on the nervous system, while the D'Arsonval current acts but little on the nerves. It is recommended for central neurosis and sensory disorders, both internal and external, acute gout, shooting pains of rheumatic affections and sub-acute arthritis and lumbago. It is recommended as a stimulant for overcoming the fatigue

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of severe mental work, increasing the blood pressure, and creating a fuller and better respiration. The treatment is of about twenty minutes' duration.

While permeating electricity may be counted as a factor in electro-therapeutics it cannot at present be said to hold any position, as its use has been limited to one or two observers only, and even in their hands nothing very definite has been discovered.

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CHAPTER XVI.

SPECIAL THERAPEUTICS.

Rheumatism and Allied Diseases.—Under this general heading it is proposed to consider all those diseases which naturally fall under a similar line of treatment, irrespective of their etiology or pathology, such as the various forms of rheumatism, neuralgia, sciatica, neuritis and synovitis.

Articular Rheumatism.—It is very generally admitted that high frequency currents are not beneficial in acute rheumatic or gouty atttacks, but that their good effects are often manifest in sub-acute conditions, and that they are very useful in chronic rheumatism and gout. Various methods have been employed in their application, but that which has proved most beneficial is, first, auto-condensation, say from five to ten minutes, according as it is well borne, and then local applications over the painful places with glass electrodes. If there be deposits in the joints, it will be well to first paint with iodine the area to be treated locally. This decreases the resistance, and also may assist in absorption. The local treatment may be given from two to five minutes for each affected spot. From the nature of the lesions treated improvement must be slow, yet it is quite constant. The good effects of this treatment lie in the power of high frequency currents, first, to increase the excretions, by throwing off products

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which might act as an exciting cause, such as uric acid, which is one of its physiological actions when administered by auto-condensation; and, second, to obtain by the local action an increase of nutrition to the part, increase of power of imbibition and absorption, and the resolving of any deposits.

One drawback to the use of high frequency currents, as here given, is that these cases require frequent treatment, every day if possible. Experience has proven that when electricity is given for chronic rheumatism, or for the repair of the damage done by an acute attack, treatments must be given often if they are to be effective. Some authorities recommend two treatments a day, but this is unnecessary. Treatments, however, should be given every day, or, at least, every other day. These patients are always more or less neurasthenic. Their nervous system is weakened, and their power of resistance is small. The author's experience is that auto-condensation, given with the frequency desirable in these cases, occasionally, instead of toning up the nervous system, which is so essential, weakens it still more, and is, therefore, often contraindicated. When, however, the patient does bear it well, while results are necessarily slow, there is no doubt that very often it will be found efficacious after all other methods have failed.

There have been cases reported where fibrous deposits in joints, such as rheumatoid arthritis or rheumatic deformans, have been greatly benefited, and even cured, by the X-ray. If the affected joint is small, such as the finger or wrist, a comparatively low tube is used, but when the hip joint or knee is

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involved a medium high tube is employed. Treatments should be given two or three times a week, and so gauged, when possible, that no erythema of the skin occurs. The deposits decrease and the joints regain their natural condition. Even the very limited experience the author has had with X-ray in fibrous deposits leads him to believe that there is a much greater field for the X-ray in fibrous deposits and fibroid tumors than has hitherto been supposed.

Static electricity has, for a number of years, been successfully employed in the treatment of articular rheumatism. It is most useful after the inflammation has reached its height and has begun to decrease. With the static wave current, beginning with a short spark, say, three to five inches, and watching results carefully, if the patient bears it well, most brilliant results are sometimes obtained. Unfortunately, however, it is not practical to give the treatment at this stage of the disease, on account of the lack of portability of a static machine and the danger attending the moving of a patient. Here is where stabile galvanic currents may be used to advantage, for the reason that they can be readily applied. As soon as conditions permit the static wave current should be administered.

The success attending the use of this current will depend largely on the way it is applied. Tinfoil should be wrapped about the joint. That this may fit thoroughly at all points, so as to insure an even diffusion, several slits should be cut at right angles along both edges, which allows them to overlap. Around this should be wound a strip of heavy metal,

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and all bound closely by a binder of some kind. Dr. Snow recommends treating several joints at the same time by having a multiple connecting rheophore. This can easily be done when the joints of the hand and wrist are involved, as no one of these joints can take the full amount of current that a machine can give off, but when larger joints are involved only one should be treated at a time. If the treatment is begun early, while the inflammation is still quite active, the spark-gap should not be more than three or five inches in length for the first two or three treatments, when, if well borne, it should be lengthened to six or eight inches. If the inflammation is not very active the long spark should be given first, for it is very essential, especially in chronic cases.

There are, however, cases which will come to a standstill even with the most powerful wave current treatment. It is best here to administer a number of clean-cut disruptive sparks from the brass ball electrode. This may be done at the same treatment, dividing it with the wave current, or the sparks may be given for a period of two to four weeks, then returning to the wave current. The latter procedure is, as a rule, preferable; both these methods are, of course, contraindicated when there is acute inflammation. Some results the author has had very recently with the combined treatment of X-ray and wave current in rheumatoid arthritis, and which are given under that heading, lead him to believe that this will be of great service in conditions following acute attacks of rheumatism.

The brush discharge should not be neglected. It

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can be given very early in the disease, and the relief it affords from pain is often very prompt. It may be given early in the treatment in conjunction with the wave current treatment, while there is yet some active inflammation, and before it would be safe to use the heavy sparks.

Electric light heat baths have been used for the cure of articular rheumatism, especially after the acuteness of the inflammation had disappeared. It assists materially in the resolution. It is here that small baths, which surround one joint only, may be used, as usually but one or two joints are affected at a time. The portability of the small bath makes it especially useful in these cases, for where the incandescent electric light circuit is it can be used. The complete bath, however, should be used when it is desired to get the eliminating effects of the bath.

Gout.—If the patient will bear the discomfort of the vigorous local application of the resonator current, by means of the glass electrode or the brush discharge, he may be very greatly relieved of the pain from an attack of gout. The mental anguish is often greater than the discomfort of the treatment. This is not to be wondered at when we consider the extreme sensitiveness of a gouty joint. A case of chronic gout should be treated the same as rheumatic deformans, which follows.

Rheumatoid Arthritis—Arthritis Deformans.—This is an exceedingly difficult disease to cure by electricity, or any other known means. The reason there is such a diversity in the results attained by different writers is because of the difference in the pathology

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of these apparently similar conditions, which is not always recognized by the physician. In those cases where the deposits are comparatively recent, when the patient is not over fifty-five years, and in fairly good physical condition, and where the deformity is due to deposits only, and not to change in structure of bone, improvement may be looked for and hope for a cure entertained. The treatment given for articular rheumatism applies to this condition also, providing one keeps in mind the less favorable prognosis.

The author has recently had some excellent results in treating recently developed arthritis deformans by the combined use of high frequency, X-ray and static currents. Treatments were given daily. At first they were given one day auto-condensation, the next X-ray, and the third static wave current. This method was, however, after three weeks changed to auto-condensation, 250 ma., for eight minutes, and static wave for ten minutes every other day, and the alternate days X-ray for eight minutes and static wave ten minutes. This treatment gave the best results. The static wave current has both local and general effect. Auto-condensation is a tonic and expels uric acid from the system. It does not, however, always act as a tonic, and the patient should be carefully watched, as it is very essential that he should not be depressed in any of his physical powers. By discontinuing the X-ray and continuing with the other two, the author is convinced that the most important of the three is the X-ray, but that all combined give the best results. The parts treated with the X-ray should be care-

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fully watched, and on the first appearance of erythema the treatment should be discontinued for the time. These cases are, however, of recent date, and it is not best to make too great prophecies on very recent experience, but the good results obtained make it certain that in well selected cases we may expect much.

The electric light heat bath has been very highly recommended for rheumatic deformans and gout. It is here that the general bath with its power to stimulate the action of the skin, and to throw off uric acid, is so useful. Care should be exercised in administering it, especially in those chronic cases where the bodily strength is greatly reduced. The author believes it is impossible to produce any lasting good effects by any measure which reduces the general health. The general condition should be carefully watched, and the bath so regulated that it does not reduce, but rather build up, the general physical condition.

Synovitis.—Electricity is of use in synovitis, but it should be given with great care. No electrical treatment should be given during the rising stage of inflammation. When the acute condition is passing away the static wave current may be administered, observing all the rules and precautions that are given in the treatment of articular rheumatism. Local high frequency applications with the glass electrode may also be given along with the wave current. A little later, when the inflammation has quite subsided, leaving mostly a chronic soreness, the brush discharge may be substituted for the high frequency, although the author prefers high fre-

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quency. When there is a very chronic condition, a passive congestion with deposits, long sparks from the brass ball electrode should be given. If there is much deposit a few X-ray treatments will be of use. This treatment if faithfully carried out, together with rest, proper care, and so on, will cure all cases of simple synovitis, but it is contraindicated when there is pus present, and will be of no use when there is ankylosis.

Tubercular Joints.—While many of the experimenters claim that X-ray does not destroy the tubercle bacillus, clinical reports are numerous of its power to cure serious tubercular affections. Tubercular joint disease is one of these. That it has a very decided action in relieving these cases there can be no doubt. The best method of treatment is to give an X-ray application, using a medium hard tube for about eight minutes, followed by static wave current for ten minutes. That the treatments may be given often without fear of X-ray burns, each side of the joint should be exposed separately. The metal covering of the joint in the wave application should be carefully applied, every part being well fitted. The grounding of the opposite pole should be very complete, and the spark-gap should be six or seven inches in length. These are all important points to success.

Muscular Rheumatism.—For acute muscular spasm, such as we often find in acute attacks of lumbago or intercostal rheumatism, stabile galvanism is superior to any other form of electrical application. The static wave current may be used early in inflammatory conditions; so may the local, as well as

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general, high frequency applications, but it is best not to use these when the symptoms are too acute, as they sometimes act as an exciting cause of spasm. When, however, the tendency to spasm disappears, and there is left a soreness and stiffness with an aching pain, the brush discharge, local high frequency applications, or general D'Arsonvalism will all be of benefit, and will eventually cure the case; long static sparks with the large brass ball electrode will generally be found of greatest utility if the case shows a tendency to become chronic.

There is a class of cases met with in elderly or middle-aged people who lead a sedentary life which is often diagnosed as muscular rheumatism, but which partakes more of a general rheumatic attack. Certain muscles will be involved for a few days. Then the pain will apparently run along the course of certain nerves; again a joint will become very sore and painful, may be swollen slightly, but only slightly. Perhaps the appellation Rheumatic Diathesis fits this condition better than any other known to-day. The tonic effects of static breeze, and the wave current applied over the painful places, will be of great service here. It is, however, in this class of cases that auto-condensation has, in the author's experience, proved most useful, giving from 200 to 300 ma. If the patient be much depressed and needs a tonic, static treatments may be occasionally alternated with high frequency.

Sciatica. — Sciatica is one condition which it is claimed auto-condensation aggravates. The author has tried it in some half dozen cases, and has not noted this aggravation, neither has he seen any

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benefits from it. The local application of high frequency currents will often relieve in the acute stage, probably in part owing to its counterirritating effect. When there is a distinct neuritis the wave current should be used as recommended under neuritis, and in these cases will be found of use when nothing else will suit. The author believes there are comparatively few of the cases of sciatica which come under the care of a physician, and are not distinctly inflammatory, that are not due to a state of malnutrition of the nerves, accompanied with congestion of the sheath, and it is in the treatment of this condition that it is most successful.

In the author's hands the treatment found most satifactory is to begin, when there is much sensitiveness present, with positive static breeze, negative insulation. After a few treatments, which should be light, increase to a static spray, and again, as the case improves, use the static brush discharge. Sparks are seldom required, but there will be cases in which they are necessary to a cure, especially in those conditions where the nerve needs a violent stimulation to arouse it from the paralytic condition into which it has fallen. Under this treatment the limb will fill out, the circulation will improve, and there will be an increase in strength and weight. It is necessary to give the treatment often, daily at first, and to apply it for fifteen or twenty minutes at each treatment.

Neuritis.—Neuritis is a very painful and a very tedious disease. Most cases treated as neuritis are more of a neuralgic character, which has, from a faulty nutrition, become more or less chronic.

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There is no disease more trying to both doctor and patient than a true neuritis. There are many different types of neuritis, those in which the entire nerve is involved, and those where the sheath only is involved. The former is characterized by very severe pain, complete loss of function of the nerve, as evidenced by paralysis and interference with nutrition of the part supplied by the nerve. The other form is much less severe, the principal symptom being pain, there being but little disturbance of function or nutrition.

The treatment of neuritis will necessarily differ with different conditions. Auto-condensation or auto-conduction does not seem to be indicated in the acute stages, and it is of doubtful utility in any stage. During a very acute attack, especially of the interstitial type, it is better, at first, not to treat the part with any kind of electricity. When, however, the acuteness has passed away to a degree, or in the milder form, when the sheath alone is involved, electricity may be administered with advantage. A not very vigorous local application with the glass electrode from the resonator may be applied with relief of the pain. Static breeze spray, or even brush discharge, may be given with good results.

The treatment recommended by the author, is to give the static wave current, applying the electrode along the course of the nerve, over the site of the inflammation. It is important that this electrode be fitted very carefully and cover quite a wide strip. To this is attached the positive pole. If the part is very sensitive to the treatment do not ground the negative pole at first by attaching to the gas or

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water pipe, but by simply throwing the chain on the floor and using a spark which does not cause discomfort. As soon as the patient can bear a spark one or two inches in length with the negative thoroughly grounded it should be done. This treatment should not be given for more than ten minutes, as it is apt to cause disagreeable feelings in the affected part. Following this local high frequency application may be given over the site of inflammation for one or two minutes. When the disease becomes chronic a few sparks from the large brass ball electrode will advance it toward a cure.

The X-ray has been recommended for neuritis. The author's experience with this treatment, limited to one case, did not prove successful.

Neuralgia.— Electricity is certainly beneficial in neuralgia, but there is no disease which taxes the judgment of the physician more. The indications given by different physicians for the use of certain kinds of electrical treatment in this form, or that form, of neuralgia, fail so often that they are not worth much study. After the specially indicated treatment has failed, it may be found that another kind of treatment, not indicated according to the rules laid down, will most promptly relieve the condition. The reason of all this uncertainty is often due to a lack of knowledge of the etiology and pathology of the condition present. Superficial neuralgia has been very often relieved by a vigorous application by the resonator current with the glass electrode. Other cases are relieved by means of static breeze, or spray, or brush discharge, while still others require heavy sparks. The static wave

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current does not hold the high place here that it does in neuritis, but when it is followed by an application of the local high frequency current so as to produce a vigorous counter irritation its results are very good. If there is not much sensitiveness the spark will often relieve cases when no other form of treatment is of avail. It is always best, however, to begin with milder methods, such as the spray or brush discharge, before the spark is resorted to. The prognosis will depend largely on the depth of the location of the nerve, as well as the severity and chronic condition of the patient.

Obesity.—There appears to be a great difference of opinion as to the power of high frequency currents to reduce superfluous fat. D'Arsonval, and many others, have claimed excellent results in these cases, as shown by the increase in the amount of urea excreted, and a steadier and more vigorous heart action. Other observers have failed to obtain such results, and deny its efficacy. The author has had no experience and cannot, therefore, speak with authority. The methods of treatment employed by D'Arsonval and others who have reported the greatest success have been auto-conduction, the successful treatments having covered a period of from three to six months.

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CHAPTER XVII.

PULMONARY TUBERCULOSIS AND OTHER DISEASES.

Pulmonary Tuberculosis. — During the last two or three years pulmonary tuberculosis has been the subject of much experimentation with the X-ray in America, and high frequency currents in Europe. Roentgen ray treatments, when given faithfully, and where the case is not too far advanced, will produce certain results in the way of relieving the cough, reducing the amount of expectoration, making the patient more hopeful, and, perhaps, arrests, to a degree, the progress of the disease, but the author has yet to see a case of active tuberculosis treated by X-ray alone that has not gone on to a fatal termination. This statement is made on the observation of a large number of cases. In some the tubercle bacillus has disappeared from the sputum, yet the disease has gone on progressing.

There has been much controversy regarding the efficacy of high frequency currents in pulmonary tuberculosis, and a very strong consensus of opinion exists among those who have used it that it is nearly always more or less beneficial; but most of these observers are very guarded as to its power to establish a cure. There are, however, now many cases of more than two years' standing that remain in as good condition as when they discontinued treat-

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ment. Some of the treatments have been given locally by the administration of the effleuve from the Oudin resonator. The probable action of these currents in the treatment of pulmonary tuberculosis is in its power to increase oxygen in the blood. If this be true, auto-condensation should be employed, followed by the local application of the effleuve over the chest and back.

Dr. Chisholm Williams has given the results of upward of forty cases treated by high frequency currents. His method was to administer auto-condensation for ten to twenty minutes, giving from 200 to 300 ma., and sometimes even higher. The first eleven of his cases received the effleuve over the chest, but this was abandoned on account of lack of time; he could not, therefore, have prized this form of administration very highly. Apparently he considers the guidance of the treatment is the temperature. If there is an increase of the temperature following the application it should be lessened both as to frequency and length. As the condition improves this tendency to rise of temperature after treatment disappears, and when a patient can take a treatment of a half hour daily for one week, and the temperature remain normal or subnormal, the disease is at least arrested. The more severe the condition the quicker do the reactions manifest themselves. He believes that the treatment causes at first an overgrowth of the bacillus, and finally an atrophy and destruction of it. His cases show remarkable results, far better than with the X-ray treatment. The patients gain steadily in weight, and improve in their general condition.

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It can be safely asserted that this treatment will have a beneficial effect on the larger majority of those cases which are not too far advanced; that it will permanently cure these cases should not yet be stated, as sufficient data has not been gathered, and sufficient time has not elapsed to determine this point definitely. Under this treatment the general health improves, the expectoration grows less, the tubercle bacillus decreases and disappears, and the natural optimistic tendency of the patient increases. So marked are these conditions at times that it is difficult to make the patient understand the necessity of continuing the treatments.

Diseases of the Nose and Throat.—High frequency currents have already gained for themselves a place in the armamentarium of specialists in this branch. It is the local application by means of glass electrode, various sizes and shapes having been specially devised that is employed, and no use has been made of D'Arsonvalzation.

The local application of the resonator current has been found useful in enlargements of the Schneiderian membrane over the turbinated bones. It is naturally of no use when there are enlarged bones or projecting cartilages. Neither is it of permanent use in true hypertrophies, but it is of great use in vascular enlargements, spongy enlargement, where from the least irritation the membranes fill with blood and become enlarged. This condition is often due to deep-seated causes, which should first be removed if a permanent cure is to be made; but there are cases which this treatment alone will quite promptly and effectively relieve; these are when the membrane only is affected.

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A small glass electrode, made for the purpose, is selected, and by the aid of the laryngoscopic light it is placed directly against the enlargement. A comparatively weak current should be used, as these membranes are very sensitive, and if an overdose is administered a very disagreeable dryness, with correspondingly disagreeable sensations in the head, will be the result. In introducing the electrode, if the current is already turned on, the operator or patient should have his fingers tightly grasped on the approximate end of the electrode, so as to take off the current, for if sparks pass to the nose they are most uncomfortable and may make the patient very nervous. The duration of the treatment, and the frequency with which they should be given, must be governed by conditions and results. Generally a three to four minutes' treatment, three times a week, will suffice, but it may be necessary to treat oftener and longer.

Post-pharyngeal catarrh is ofttimes successfully treated by high frequency currents. The method of application is the same as given above, for which a special electrode has been devised. With a good laryngoscopic light the tongue is depressed, and the electrode, with a projection which will reach well up behind the palate, is applied. This electrode should be made so that only the flat surface of the end of the projecting part conveys the current, for if the soft palate receives the sparks it would be very disagreeable, and with a perfectly constructed electrode this may be avoided and the treatment given without discomfort. The symptoms of the catarrh will decrease, and the membrane take on a much healthier appearance.

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It is claimed that tuberculosis of the pharynx may be cured by the same treatment, applications being made daily for from five to ten minutes. The author cannot speak from experience on this point.

Dilatation of the Heart.—It has long been known that a vigorous application of the faradic brush over the region of the apex of the heart in cases of dilatation, or in those cases where there has developed a loss of compensation, will greatly improve the action, temporarily at least. The high frequency current furnishes us with a more efficient means, and, at the same time, it is a more agreeable treatment. The *modus operandi* of its action is, of course, reflex, but how this action takes place is difficult to determine. It probably does not produce contraction of the wall of a dilated heart, at least to any marked degree. Its action is undoubtedly through some nerve stimulus.

A vigorous local application by means of a glass electrode is made over a wide area in the region of the apex of the heart for from three to five minutes. The patient should then be allowed to rest for ten minutes, when it will generally be found there is a marked improvement in the heart's action. If after two or three applications there is no perceptible improvement the case is not one to be treated by this method. If the treatments are successful in toning up the heart temporarily, it may safely be assumed that treatments given once a day, or every two, three or four days, and, perhaps, at even longer intervals, will keep the patient very comfortable. This is not intended in any way as a permanent cure, but in not too critical cases there may be quite lasting effects after a course of treatment.

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Diabetes.—Numerous cases of diabetes have been reported cured by high frequency currents. Of course, with this as well as with any other treatment the greatest care should be taken regarding the diet. Auto-conduction, auto-condensation and local effleuve over the entire abdominal regions, both front and back, have been used. The author recommends that auto-condensations be given for five minutes daily, followed by the effleuve for five minutes. Both the quantity of urine and the amount of sugar passed will decrease under this treatment; and there is no doubt that many cases have remained apparently well for two years.

In one case treated by the author the patient had continued to follow a diet for nine months, with the result of having reduced the sugar from three per cent. to one and one-quarter per cent. Treatments were generally by auto-condensation and effleuve, as recommended above, every other day. At the end of the fourth week the sugar disappeared entirely. Treatments were discontinued, and the same regimen continued. In fifteen days there was less than one per cent. of sugar. Treatments were again resumed, with the result that the sugar again disappeared at the end of the first week. The case is still under treatment.

The static wave current certainly possesses some power in reducing the amount of sugar passed by diabetics. The electrode should be applied for eight or ten minutes over the region of the kidneys, and for the same length of time over the liver. The electrode should be made to fit the parts well, and the sparks between the terminals should be six or eight inches in length.

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Bright's Disease.—Auto-conduction and auto-condensation, especially the latter, increases the excretion of urea. This action may be utilized in treating various forms of Bright's disease. It removes, to a degree, the danger that arises from uræmic poisoning, but that high frequency currents produce any change in the kidneys, or that it has ever even symptomatically cured Bright's disease, no evidence has yet been produced.

Anæmia and Chlorosis.—It is claimed that one of the physiological actions of high frequency currents is to increase the blood corpuscles, and also to increase the hemoglobin in the red corpuscles; we should, therefore, think of its application in anæmia and chlorosis. At any rate, it should be an excellent adjunct to other treatment. Auto-condensation is the best method of giving it. Treatments should be given three times a week for from five to ten minutes. Patients should be carefully watched under this treatment, and if they show a tendency to nervous debility or depression treatments should be at once discontinued.

Static electricity, either as a breeze or wave current, preferably the former, assists the ordinary methods of treating these diseases, in the way of building up the nervous system and giving tone and strength to the patient, but it is not claimed to possess any special power in increasing either the hemoglobin, or the number of corpuscles.

Hæmorrhoids.—From time to time electricity in its various forms has been recommended for hæmorrhoids. These treatments have been more or less successful, but, all things taken into consideration,

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they have not kept pace with surgery and have been largely discontinued.

High frequency currents have, however, lately been used for hæmorrhoids, and have proved to be of benefit. Their action is both antiphlogistic and resolvent. That this treatment cures many cases there is no doubt, but it is by no means a cure-all, as has been claimed by some enthusiasts working in this field. It appears to be best adapted to those cases which are chronic, but are not continuous coming and going, usually in young active people, and not complicated by much thickening of the surrounding tissues.

The method of application is by means of a glass vacuum or condenser electrode. When the hæmorrhoids are external the electrode may be held a short distance away, so as to obtain the benefit of the shower of sparks, as this is more efficient. When internal the electrode is placed within the sphincter ani, and, consequently, the sparks are shorter and milder. Treatment should be given for about eight minutes, and when given internally even a little longer. If there is but a small point to be treated in external hæmorrhoids the treatments should not be given so long if the electrode is held so as to produce a shower of longer sparks, as it might produce destruction of the sack and a slough as a result.

The congestion will be relieved, as a rule, after eight or ten treatments, but it is necessary to continue the treatment that the resolution may be complete. If the sphincter is at all rigid and spasmodic a larger sized electrode should be used, from time

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to time, so as to dilate it. Constipation, a very common cause of hæmorrhoids, may be treated in conjunction with the treatment for hæmorrhoids, the technic for which is given further on.

Pruritus ani, when an accompaniment of hæmorrhoids and not due to irritation higher up, or to worms, will be promptly relieved by this treatment.

Fissure Ani.—The treatment recommended for internal hæmorrhoids will often be found beneficial for fissure. The principle involved here, however, is to use increasing electrodes with each treatment, if possible, until the sphincter is thoroughly dilated.

Prolapsus Ani.—The treatment with high frequency currents recommended for internal hæmorrhoids, only that the electrode should be placed a little higher up than for ordinary hæmorrhoids, will be found most useful for prolapsus ani. There is no treatment equal to it for giving tone to both muscle and membrane.

Constipation.—High frequency currents have been very successfully used in this country for constipation. Dr. W. H. Dieffenbach deserves much credit for the development of this treatment. Here it is that we depend upon the reflex action of the current. The electrode is an important part, and has been described in the section on General Electro-Therapeutics, and is illustrated in Fig. LXIV. It is important that an inner chamber be placed inside the electrode at the part which comes in contact with the sphincter. This is to protect the sphincter from the discharge, which might make it very irritable and sore, something that should be most carefully avoided, as a sore, irritable sphincter might

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be in itself the cause of constipation. At the same time this chamber prevents the escape of the charge being given off at that point, otherwise which would necessarily happen on account of the closeness of contact of the sphincter with the electrode.

It is important, also, that the electrodes used for this purpose should be made of gradually increasing sizes, so that the sphincter may be stretched with each succeeding treatment. In giving the treatment an electrode is chosen as large as can be passed through the sphincter without causing too much pain. This should be introduced well up into the rectum, and the current from the resonator, or one pole of the hyperstatic instrument, be given. Occasionally there are persons so susceptible to this treatment that care must be exercised or violent diarrhetic discharges will be the result. This, however, seldom occurs. As a rule, the constipation disappears gradually.

So far as the author's experience goes, this is a most successful treatment and is very permanent in its results, providing due care as to diet and habits be exercised after the treatments have been discontinued. It is quite as successful in those cases which have used enemas as in those which have not, differing in this respect from galvanism. There will be found cases which it does not affect beneficially, but just what the conditions are that militate against success cannot be told at present. In the most stubborn cases treatment should be given daily for from ten to twenty minutes, and strong currents should be used, as they are well borne, and weaker ones seem to be ineffective. After improve-

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ment has set in, three times, or less, a week will suffice, and treatment may be discontinued gradually until one is given in two weeks, when, if the bowels continue to act regularly, it may be discontinued altogether.

The greatest necessity of regularity in the habits of the patient in making systematic attempts at defecation, as well as regulation of the diet and general hygiene, cannot be too strongly urged.

Dyspepsia.—For dyspepsia high frequency currents should be given generally by auto-condensation, and locally by effleuve over the hypergastric regions, as well as over the spine. This will ofttimes relieve acute and other forms of dyspepsia. It acts as a tonic on the stomach walls, increasing the tone, and, at the same time, increasing the circulation and nutritive fluids. It is only in conditions where there is atony present that it is useful, and it should never be employed in inflammatory or congested conditions of the stomach.

Atonic Dilation of the Stomach.—Dr. Chisholm Williams has reported some remarkable results of atonic dilation of the stomach by a treatment similar to that recommended for indigestion. He gave local effleuve for five minutes, and auto-condensation for ten minutes.

Gonorrhœa—Gleet.—Various have been the methods of using high frequency currents in treating gonorrhœa. One is to wrap the organ in dampened linen, and enclose the whole in tinfoil, which serves as an electrode; this is attached to one pole of the D'Arsonval solenoid, while the other pole is attached to a metal electrode applied to the perineum. Another

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method is to immerse the organ in a weak solution of boracic acid, the electrode being placed in the solution, thus making the solution itself a contact electrode, while the other electrode, as before, is placed on the perineum. It is claimed that this treatment very soon,—within three or four days,—reduces the inflammation and greatly lessens the discharge. The author has never tried either of these methods and cannot speak personally of their value, but they certainly possess the merit of being simple, easily given, and devoid of danger, as well as being applicable to the acute stage where we have few remedies that are capable of cutting short the inflammatory stage.

Another method of treating gonorrhœa is to introduce a small urethral vacuum or condenser electrode into the urethra, and pass a very weak current from the resonator or hyperstatic machine. This, in the author's opinion, should not be used in the acute, or even in sub-acute stages of the disease. Twice, to the author's knowledge, has epididymitis followed an application of this kind in acute attacks. It is, however, often a successful treatment for those cases of gleet where the diseased patch is located in front of the membranous urethra. The author should hesitate at this time to recommend it for the membranous portion of the urethra, or the prostatic urethra, except in very skilled hands, when it may be used with excellent results.

In gleet, if there exists a stricture, it should be first cured by the means best suited to the case; cutting, dilation or electrolysis. No high frequency

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treatment of gleet should be undertaken while the stricture exists. A large sized glass electrode, which can be introduced without danger, should be used, and it is perhaps quite unnecessary to dwell upon the great care that should be exercised to prevent the breaking of it in the urethra. A weak current from the resonator, or hyperstatic, is allowed to pass for not more than two minutes. If this is well borne it may be increased to three or four minutes later on. The efficacy of this treatment is probably owing to two distinct actions of the high frequency currents; one the bactericidal properties which it possesses, and the other the increase of tone to the parts, and increase of arterial blood, and, consequently, increased nutrition.

Hypertrophy of the Prostate Gland.—High frequency currents have been recommended for this condition, but, like other forms of electricity, high frequency is of no value in reducing general hypertrophy. It does seem to have a good effect in reducing congestion at times, and usually acts with promptness. The glass vacuum electrode is used, made on the same principle as the one for treating the rectum, with inner compartment for the protection of the sphincter ani, except that it has a flatter surface that it may the better fit over the prostate. The current from the hyperstatic, or resonator, may be given from five to ten minutes daily. Oftentimes in the course of this disease there appear certain symptoms which are very annoying to the patient. These are probably due to an increase of the congestion from some unknown cause, and consequent increased irritation and disturbance of the reflexes. It is for

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these symptoms that high frequency currents are most successful, and they will often act with great promptness in relieving the symptoms; but this relief is not due to any actual reduction of the prostate.

The disease described as prostatorrhœa, when due to a simple congestion, may be successfully treated by applying the glass electrode through the urethra as described above for gleet. The danger of handling a glass electrode in the deep urethra should not be lost sight of, and it is only in skilled hands that it should be used.

Impotence.—The undoubted fact that high frequency currents, especially auto-condensation, aggravate spermatorrhœa in a large majority of cases, is, in itself, proof that they produce a stimulating effect upon these organs. Various methods have been tried, and success has been the reward in a large number of cases of functional impotence. It should be remembered that suggestion has much to do with the cure of these cases, and this should be taken into consideration in summing up the benefits derived from high frequency currents. The treatment should be both general and local. Auto-condensation is by far the best general treatment, and should be given for ten minutes if it does not produce reactional effects, which are manifested by over-stimulation. The local treatment may be given by the glass electrodes over the perineum, groins and lumbar regions. The treatment is not applicable to that form of functional impotence characterized as irritable impotence, as it will, by the stimulation, increase the irritability.

The static wave current has been successfully

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used for this condition. The strong spark is given over the back, and less severe ones over the perineum, as well as friction sparks over the penis and testicles. The static wave current has been applied successfully, the organs being wrapped in tinfoil and the length of spark gauged by the feelings of the patient. Patients differ greatly in the ability to bear long sparks between the electrodes in this condition; while some will complain when sparks are two inches long, others will bear them when they are six to eight inches long. An electrode may be placed in the rectum, and the wave current administered in this way. This treatment will have good effect on those cases of functional impotence which are characterized by loss of erection only, and not in those cases of irritable impotence characterized by a very early ejaculation. In the latter condition it may aggravate rather than improve.

Gynæcology.—It can hardly be said that high frequency or static electricity to-day holds a place in gynæcology. This is undoubtedly owing to the fact that experiments with these forms of electrical manifestations have not been made by gynæcologists. That static electricity will ever hold a prominent place the author doubts, but from the very marked results he has had in a few cases with high frequency currents, he ventures the prediction that in a half score of years this will become one of the most important agents in the hands of gynæcologists. For the relief of pain in the ovaries, when not due to organic causes, or for a general pelvic pain, high frequency currents applied by means of a glass vacuum or condenser electrode, are most effectual.

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The electrode should have a non-conducting or inner cone department in that portion which passes through the vulva, so as to protect this sensitive part, and also to concentrate the current around the cervix. This same treatment will often relieve the most obstinate and obscure uterine symptoms, especially in women about the time of the menopause.

It is in those cases where there is a relaxed general tone of the pelvic organs, and probably of the uterine wall as well, that the treatment is most efficacious, and not when there is a chronic endometritis. The treatment is given to the part by introducing a glass uterine electrode. It is here, of course, necessary to be very cautious, as an accident in breaking the electrode might cause an immense amount of trouble. The action here is easier to comprehend. In the first place, there is a great stimulant applied directly to the part, a stimulant to both nerve and muscle fiber. In the second place, we have one of the most powerful superficial germicides, a germicide that will destroy bacteria of both high and low order. In the third place, powerful discharges can be borne here without inconvenience. What more can be desired in a case of fungoid endometritis? Its action on chronic endo-cervicitis, and in some cases of erosion of the cervix, is prompt. When applied in the vagina it will temporarily benefit a vesico-vaginitis, and the general toning up of the organs is marked.

In dysmenorrhœa, when due to a neurotic condition, the local application of the current to the vagina, combined with auto-condensation or general static treatment, either the spray or the wave cur-

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rent applied with a large electrode over the lumbar region, will be of great benefit. The same treatment is also excellent for amenorrhœa.

The X-ray has proved of value in destroying fibrous tumors of the uterus, and also in causing an absorption of cellular deposits, but as the treatment for these conditions does not differ from the X-ray for cancer of the uterus the reader is referred to the chapter on malignant growths.

Gonorrhœal Vaginitis.—Success has been reported in this disease by the application of high frequency currents. The method employed is to pack the vagina with linen soaked in a solution of boracic acid. In the middle of this a wire is placed, attached by means of rheophores to the end of a D'Arsonval coil, while the other electrode metal plate is placed on the perineum. It is claimed that not only does this treatment have a desirable effect upon the vaginal walls, but, when taken early, prevents the disease going up the urethra or into the cervix.

Urethral Caruncle.—Dr. G. H. Stover has reported two cases of this painful affection that have been cured by X-ray. He was led to use the X-ray by the fact that, these growths being quite vascular, the power of the X-ray in causing obliteration endarteritis would produce a cure. He used a fairly low tube and the surrounding parts were carefully protected. One case of fifteen years' standing, where the caruncle had been removed twice with a knife, required twenty-five treatments; while the other, which had been removed six years previous, and had promptly returned, required only six exposures.

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Dr. W. H. Dieffenbach reports curing a case of urethral caruncle with radium 1 m.m., the aluminum tube being inserted into the urethra and the lesion treated for thirty minutes, three times a week. After ten treatments the parts treated became oedematous and treatment was suspended. Examination two weeks after cessation of treatment showed the entire disappearance of the crauncle and restitution of the integrity of the tissues.

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CHAPTER XVIII.

SKIN DISEASES.

Lupus Vulgaris.—High frequency currents have been used successfully in the treatment of lupus vulgaris. General electrification, such as auto-condensation, has been given along with the local application of the glass electrode. If this local application is given with sufficient care it will sometimes cure a small tuberculous patch of the skin. However, it has failed to be of use in more severe cases, and so inferior is it to other methods of treatment, especially the Finsen, that only the lack of opportunity to try the Finsen method would warrant anyone in treating a case of lupus vulgaris with high frequency currents.

The X-ray possesses some power over lupus vulgaris. It has been thought in America that it possessed greater power than the Finsen treatment. This is because the Finsen treatment has not been properly understood in this country. The lamps used have been very defective, and the methods employed incomplete. The X-ray, however, does possess qualities which recommend it in the treatment of lupus vulgaris, but it is very inferior to the Finsen method, both as to the cure of the disease and because the deformity from the cicatricial tissues remains. The X-ray treatment is simple, yet, for all, must be given with great care. It should be remem-

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bered that new tubercles are constantly forming at the edges and extending outwards. The action of

FIG. LXXIII.—LUPUS VULGARIS.

the ray should be around the edges as much as in any other place. Lupus spots do not appear to

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FIG. LXXIV.—SAME AS FIG. LXXIII.—AFTER THREE WEEKS TREATMENT WITH X-RAY. PATIENT REMAINING WELL.

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burn by X-ray as easily as normal tissue. The treatments may be given two or three times a week, for from five to eight minutes. If erythema appears treatment should be discontinued for awhile.

There are physicians who believe that the best method is to produce an X-ray burn, causing destruction of all the lupus tissues. This method has no advantages, and many disadvantages; the chief disadvantage is that it leaves an unsightly scar, while with the milder method scarcely a perceptible scar is left.

If this treatment is to be successful the tubercles dry up and come off in scales, leaving a healthy base. Treatments should be continued for a few weeks after the last tubercle has disappeared. The X-ray is by no means a universal cure for lupus vulgaris. It often fails, especially when the disease has reached the mucous lining of any cavity, such as the nose. Several weeks or months will be required to complete the cure.

The Finsen treatment is always a safe and very sure cure for lupus vulgaris. Before reading this page one should read carefully what has been said, in previous sections of this book, on the Finsen lamp, and the physiological action of the chemical rays. Without a proper knowledge of these factors one will not have success, for the importance of having proper light and focus tube must be borne in mind. The technic of the treatment is simple. After the lamp has been properly focused, two compartments filled with water, and the conductors conveying water through the head of the tube and the compressor adjusted, the operator selects the place to

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be treated. This should be a point that shows signs of most activity. Bear in mind that the edges are at the points to be first attacked, as here is the place that the new tubercles are constantly forming. Later on, the places which have sufficiently recovered from the reaction is the spot chosen.

After the spot has been selected, it is thoroughly cleansed, if there be any exudated secretion on it, as

FIG. LXXV.—LUPUS ERYTHEMATOSUS.

this has a tendency to obstruct the ray. Dioxygen diluted is perhaps best for this purpose. The pressure bulb, of the right size and shape, is now placed over the selected spot, and pressure made sufficient to press the blood from the part. This pressure should be constant for the entire treatment, which is to continue for one hour, or even a little longer. The

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stated period in the Finsen Institute is seventy minutes. If all the precautions have been taken to filter out the heat rays there will be no burning. In fact, the parts treated will not be perceptibly warmer than the surrounding tissue. It is important when such long treatments are required, that both the patient and the operator should be so placed that their positions are comfortable. This is best accomplished by laying the patient on an operating table, while the operator is seated by the side in a perfectly comfortable position. If the lupus is near the eye, that should be protected by covering it with a cloth, and the operator's eyes with smoked spectacles.

After a few hours, varying from ten to twenty, the part treated becomes pithy, looks slightly angry, and may be œdematous. This does not, as a rule, however, cause any pain or any other inconvenience. This congestion gradually decreases, leaving a white, scaly mass which flakes off, and in from three to seven days the part can be treated again. The entire lupus should be gone over in this way, working from the edges inward. If the patch is large treatment should be given every day, and if it shows signs of activity it should be treated in two or three places each day. The number of times each point will have to be treated varies from two to ten, or even twenty. The destroyed spot becomes dry and scaly and drops off, healthy tissue is formed, and the place heals with very little scarring. The case should be kept under surveillance for a year or two, and if there is a tendency of the lupus to return treatment should be again resumed, which if given early enough will be required only a few times.

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FIG. LXXVI.—SAME AS FIG. LXXV.—AFTER EIGHTEEN MONTHS TREATMENT WITH X-RAY.

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Lupus Erythematosus.—It must be admitted that while the light treatment is successful in lupus erythematosus, its success is not so uniform as it is with lupus vulgaris. The treatment recommended for the latter applies here as well. If it is to be successful the hypertrophied tissue becomes hard, dry and scaly, and finally comes off, leaving a healthy tissue. High frequency currents given moderately strong with the glass electrode from the resonator are quite successful here. The surest method is to use the Finsen ray for a certain period, until the parts become loose and spongy, and then finish with high frequency currents. If one does not possess a Finsen lamp, the X-ray may be used instead, but it does not possess the same value. Months will be required to complete the cure of a bad case.

Success by any method of treating lupus erythematosus seems to depend upon the action obtained. If there is a good reaction there will be destruction of the tissue, which dry up and come off in scales. One layer of such scales does not reach to the bottom of these diseased tissue. Another treatment over the same spot will bring away another layer, until all the lupus tissue has been destroyed. Lupus erythematosus, as a rule, spreads over a wider space than an ordinary case of lupus vulgaris, and more time to complete a cure will be required.

Pigmentary Nævus. The Finsen treatment, such as described for lupus, will often remove pigmentary nævi. It is not necessary to treat any one spot as long as an hour. The author has found, however, that the fifteen minutes' treatment recommended by some is too short a period. After a few treatments, vary-

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ing from twenty to forty minutes, the operator will be able to judge of the amount of time required. The treatments should be given for a sufficient length of time to cause a slight reaction, only, however, very slight, which causes a fine scaling of the superficial epithelium. After the pigmental spot has been gone over several times, the color will be seen to fade away. It is not often that the complexion is perfectly matched with the surrounding unpigmented spot.

Alopecia Areata—Bald Head. High frequency currents have proved most effective in these conditions, especially alopecia areata. The success in bald heads, of course, will depend upon the amount of destruction there has been of the follicles by diseased processes. The parts should first be smeared with vaseline, and rubbed in to a degree. The treatment is then given with glass electrodes attached to the resonator or hyperstatic machine; it should be given as strong as can be comfortably borne, and continued in cases of bald head for five minutes, perhaps less in alopecia areata, as the spot is smaller to cover. It should be repeated at least twice a week, and if the patient can bear it, three times would be better.

The attendants who administer the treatment at the Finsen Institute find that hair grows on their fingers where the light strikes them in holding the compressors; this would indicate that the Finsen treatment might be excellent for alopecia areata.

Acne Rosacea. One of the most severe cases the author has ever seen of acne rosacea, the one that has defied all kinds of treatment for nine

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years, was promptly cured with high frequency currents. Applications were made twice a week with glass electrodes attached to the hyperstatic coil. The treatments were quite severe, leaving a deep redness which would remain for about twenty hours. The pustules dried up and the redness disappeared. When the patient first presented herself for treatment she was on a diet which she had learned from experience suited her best, and which she had been following for upwards of two years. This was not changed. Marked improvement was noticed within three weeks, when the treatments were reduced to one a week for two months. At present, a year having passed, she remains well. Six cases have been treated by this method; and, as yet, there has not been a single failure.

The X-ray has not proved successful in this disease, but the violet ray has been very effective in the Finsen Institute, and it can be utilized in conjunction with high frequency currents. The light from the Piffard, Görl and Bangs lamp failed in one case which was afterwards cured by high frequency currents. If high frequency currents should fail to produce a complete cure, the violet ray from a Finsen lamp should be given for a few weeks, until the parts become slighty pithy, and then return be made to high frequency currents.

Keloid. The X-ray has not been successful in the treatment of keloid. Finsen makes no claims for the violet ray. High frequency currents have been successful in some cases. The method of treatment is to concentrate the resonator current by means of glass electrodes upon the keloid. The application

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must be severe enough to set up a strong reaction, which is followed by desquamation. The treatments should then be repeated, perhaps several times, before a cure is complete.

Warts. The treatment recommended for keloids will effectually remove warts. If the treatment can be borne strong enough, one application will be sufficient, but, if not, three or four will be required.

Chronic Eczema. High frequency currents have been employed very successfully in the treatment of chronic eczema. When taken alone high frequency will not cure the most chronic forms; it will relieve them for a time, but the disease will return. In recent cases where there is not much change in the skin, it will be all that is required. The method employed is to give strong concentrated resonator currents by means of glass electrodes to the affected parts. Fine scales will appear and come off, leaving a healthy base. This process may have to be repeated some four or five times, and if after this the case is not cured, the X-ray should be used in conjunction with it.

In those very old cases where the skin has become thick and leathery, the combined X-ray and high frequency currents will be required. The X-ray should be given first for eight minutes, the high frequency following it for four or five minutes. It may be necessary to continue this for from three to five weeks. A soft tube should be used. If a slight erythema is produced, allow the patient to rest for a week or ten days before resuming treatments, so far as the X-ray is concerned, but the high frequency application may be continued. If the

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erythema is quite marked it will probably not be necessary to resume the treatments with the X-ray again, the high frequency being sufficient to complete a cure. In the worst cases the erythema is sometimes necessary to the cure.

Psoriasis.—Williams reports a very severe case of palma psoriasis cured by the local effleuve treatment; after eighteen months the case still remained well. Others have treated it successfully with X-ray, but it does not appear that cure is very permanent under this treatment. Freund recommends placing the tube at some distance, if the placques are quite large, and nearer if they are small, with a correspondingly shorter treatment. The very red placques gradually become lighter, and when they come off the very red base which is so characteristic of psoriasis is absent.

Ulcers.—Chronic ulcers may be aided in their healing by concentration of the resonator current, by means of the glass electrode. There is no doubt that the processes which take place here are twofold; first, the increase of nutrition and increased arterial blood to the part; and, second, the ozoneisation of the tissue. The first sign of improvement is the increased redness of the base of the ulcer, and disappearance of the mucous covering, leaving a clean bright red base on which healthy granules form. It is not necessary to continue the treatment during the entire process of healing, for the healing will continue after the processes have once started.

Hypertrichosis.—The X-ray has been successfully used for the removal of superfluous hair on women's

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faces. There seems, however, to be a great disagreement in the views of workers along this line. Some claim great success, while others state that not only have they had no success, but that the conditions were very much aggravated. These opposite effects have been due to the difference in the applications. When the hair is removed by a few applications, even if those applications be so severe as to produce destruction of tissue, the hair will return, and often return thicker than before treatments were given; and, strange as it may seem, the new growth is often curly, while having been perfectly straight before the treatments were given. This refers to the hair of the head.

On the other hand, if the treatments be long continued, for many weeks, and so moderately that no erythema, or slight, if any, appears, the hairs come off of their own accord, and the bulbous portion of the roots will be found atrophied. The face is then smooth and there is no return of the hair. It is not necessary to give treatments oftener than twice or three times a week. In some cases the hair will come off very readily after a few treatments, but that will soon cease. In these cases the length of exposure should be increased, and treatment more frequently given. The tube should not be too soft; a medium tube is best, and should be placed about eight inches from the face.

The disappearance of the hairs is very gradual, and treatment should continue for some weeks after they have disappeared. The patient is apt to be discouraged at first, as the small hairs disappear long before the larger ones do. In an ordinarily severe

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case at least six months should be given to the completion of a cure. The best guide to the severity or frequency of the treatment is to cause only the slightest erythema. If this is done the pigmentary changes will also be slight. This, of course, is not always possible, as a burn may come when least expected, and as the face is the place treated, and scars would be a deformity, the patient should be warned before treatments have begun. If she is not willing to take the responsibility, the physician had best leave the case alone. Perhaps the best results, as well as the safest, will be achieved when hard tubes energized by weak currents are employed.

Favus Capillitii. The successful treatment of this disease depends upon a complete epilation of the entire scalp. It should be remembered that it requires a very long series of treatments, even after complete epilation of the scalp, to prevent the hair from returning. If, therefore, the treatments be properly timed, baldness need not be permanent. Epilation may be accomplished best when hard tubes energized by moderately weak currents are used. After the hair falls out, which should take place in five to eight weeks, the scalp is seen to be red, exfoliation takes place, leaving pale-red oozing points, which heal in a little over a week. At this point irradiation should cease. In the course of a month small lanugo appear, and in the course of from three to four months the scalp is entirely covered with hair.

Sycosis. Various forms of sycosis have been reported cured by X-ray applications. There seems

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to be a consensus of opinion among those who have treated sycosis with the X-ray that a hard tube placed at some distance is better than a soft one placed near. The cases reported cured have required from twenty-one to sixty-one treatments to perfect the cure.

The technic employed by Kienboeck (Vienna) in folliculitis or sycosis barbæ is as follows:

"If the whole beard is attacked, the tube is placed in succession in four positions, above the right and left cheeks, in front of the lips and below the chin. Care should be taken not to have the tube too close; without this precaution the epilation would be unequal and after treatment the growth would be incomplete. It is important thoroughly to cover with lead foil the smooth areas on the face as well as the mucous membranes of the lips. After a period of latency of a week the epilation can be seen to follow the treatment, the exacerbation of inflammatory phenomena and the evacuation of abscess cavaties take place and the skin becomes smooth and intact. When the hairs grow again (after six weeks) they should be shaved and the use of the razor should be persisted in for months. The prognosis is naturally unfavorable if the disease is maintained by a cause which cannot be cured, as, for instance, by a chronic rhinitis."

The Piffard rays have been tried in an old case of sycosis at the Flower Hospital clinic and within ten treatments of two minutes at each station the area treated was cleared up, the eruption becoming dry and exfoliated in patches, leaving the healthy epidermis beneath. The Piffard lamp employed in

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these treatments was energized by a sixteen inch coil with a small Leyden jar in circuit, using six to eight amperes in primary circuit. This new ray promises to be the treatment of choice in this hitherto intractable disease if the results prove to be permanent in character.

Tubercular Glands. This disease is placed following and in the same chapter with skin diseases, as its treatment is so similar. Although it is claimed experiments have proved that the X-ray does not destroy the tubercle bacillus, yet the X-ray has cured many cases of tubercular glandular enlargement. A medium hard tube is employed and placed about eight inches from the patient, and a moderate ray used, that is, the tube should not be energized by a large volume of electricity. If the static machine is used the plates should be made to revolve slowly, and if a coil the amperage of the primary circuit should not be great. If suppuration has not taken place, the glands, if a cure is to be made, will shrink until they disappear altogether. If suppuration has taken place and a sinus exists, the discharge will gradually lessen and stop and the wound will heal. The progress in these cases is generally good, but there are some that the treatment will not reach. If the treatment is to be successful, improvement should be manifest from the fifth to the tenth application.

Tubercular Testicle.—Dieffenbach (N. A. Journal of Hom., Feb., 1905) reports the cure of a case of tubercular testicle by means of X-rays. The patient, æt. 33, had swelling and a purulent discharge from the left testicle, with several prominent nodules

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in the lower section of the organ. The discharge on microscopic examination showed the presence of Koch's tubercle bacillus in large numbers. A prominent genito-urinary surgeon who was consulted in the case advised prompt castration in order to obviate constitutional infection. Patient objected to the operation and a trial of X-rays was decided upon. Treatment was given three times a week with a medium vacuum tube, placed six inches from the lesion, duration of the radiation being five minutes, the tube being energized by a twelve plate Holtz machine. The parts in proximity to the lesion were carefully protected by double sheets of X-ray tin-foil and radio-dermatitis carefully watched for. Patient was given a two weeks' respite when dermatitis supervened upon one occasion and treatment altogether consumed fully three months, when the discharge ceased, the swelling had subsided, the nodules being shrunken. The testicle itself appeared somewhat atrophied after the course of treatment. During the treatment the patient received constitutional treatment by the family physician, which in many instances relieved intercurrent symptoms.

M. le Dr. J. Belot reports a number of cases of pruritus, pruritus with lichenfication, prurigo, lichen ruber planus, lichen corne, mycosis fungoides and premycosis, as successfully treated by the X-ray with a soft tube. His method is to allow an interval of fifteen to twenty days to elapse between any two applications; only recommence treatment when the reaction has perfectly subsided.

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CHAPTER XIX.

MALIGNANT DISEASES.

Epithelioma—Skin Carcinoma. The cure, by the X-ray, of a patient suffering from epithelioma was the starting point of the use of radio-therapy for malignant conditions. During the last two years the literature on the subject of the cure of cancer in its various forms by X-ray applications has been voluminous. From a perusal of this literature, especially the journalistic, it is evident that epithelioma is looked upon as a very curable disease, more so than any other form of malignant growth. For the past three years the author has read these journalistic claims and has faithfully tried every form of technic recommended; and yet he must admit that epithelioma has been, in his experience, one of the forms of malignant growth most incurable by the X-ray treatment. Carcinoma of the breast has proved far more curable than has epithelioma.

The author cannot say that he has ever seen any benefit in treating epithelioma of the tongue or buccal cavity with the X-ray, and he has attempted it in more than twenty cases. This is not because he has not been able to get at the disease properly in all cases. That might have accounted for the failure in some of the cases, but in others the disease has been located on the tip of the tongue, and with the Friedlander shield, using the large sized projecting tube, the power of the ray could be easily

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concentrated upon it. That it does cure some cases of epithelioma of the skin, there is no doubt, but in the author's hands comparatively few cases have been benefited, the X-ray proving less efficacious than the high power radium; in one case where the X-ray failed to heal the ulcer after a series of treatments covering a period of eight months, the ray from the Piffard Görl lamp succeeded in healing it in four months.

There has been great variety in the technic of the treatment of epithelioma. Some believe that care should be exercised not to produce even a slight erythema, and that on its first appearance the treatment should be discontinued. Others believe that at least a superficial burn should be produced, and this as promptly as possible, in order to hurry up the cure and prevent a further extension of the disease. Some operators believe their success lies in the closeness of the tube to the diseased part, and that it should not be placed more than two or three inches away; while others using a hard tube, place it some distance from the diseased part. Being a superficial disease, we should naturally expect the best results from using a moderately soft tube, yet there are those who recommend a hard tube.

The author's experience has been so unsatisfactory in this disease as compared with the reported results of many that he has no special form of technic to offer. There appears, however, to be a larger majority who believe in a moderately soft tube placed ten inches from the patient until it is learned that there exists no special susceptibility of the patient to the X-ray, when the tube is gradually placed

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nearer until it is only five or six inches away. Mild radiations are recommended, and very mild dermatitis is permitted.

If the treatment is to be successful, the surface of the ulcer will first become bright looking, and there may be a tendency to bleed. This soon passes away, and the sore begins to heal from the edges. Many months will be required to perfect a cure. If, when treating a case with the X-ray, the edges begin to raise, and become deformed and hard, or if the surrounding tissue becomes hard and infiltrated, the treatment will not be successful; every day the treatment is followed after this is loss of so much opportunity to the patient for other treatment.

Regarding post-operative treatment by the X-ray, out of seven cases where epithelioma was removed and irradiation begun immediately after the healing of the wound, all within the twenty-fifth day, there has been no recurrence, two cases being now of eighteen months' standing. In four cases, where there were distinct evidence of recurrence, in two this was shown by the breaking down of tissue with metastasis to the lymphatics. With the other two evidence of the return was confined solely to the scar; in one this was very marked, and accompanied by slight inflammatory symptoms, while with the other the scar had changed but slightly and there were no signs of inflammation. Treatment with the X-ray was not successful in any one of the four, but the last case, where the scar was involved without inflammation, was afterwards successfully treated with high power radium. Only a few months have elapsed, however, and the permanency of the cure

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cannot yet be stated. When the lymphatic gland becomes involved the X-ray is of no use.

Dr. W. J. Morton administers fluorescin, giving six drops of an aqueous solution, one, two or three times a day, along with X-ray treatment. He believes that as fluorescin fluoresces when the X-ray comes in contact with it and gives off violet rays, which is not true, by giving it internally that violet rays are given off within the tissues. This is a far fetched theory, for what changes have taken place after the ingestion of the fluorescin is not known, and whether any fluorescence takes place is doubtful. Fluorescin applied to the surface in the treatment of skin diseases at the Finsen Institute results were negative. At the clinic at the Flower Hospital Hepar sulphur is given for the same purpose. This possesses the same power of fluorescence. Hepar sulphur when given internally has decided power over pus formation, and this may possibly be accounted for by some action along this line. The experiments at the Flower Hospital have not yet been carried on long enough to warrant any conclusion to be reached.

In treating epithelioma with violet ray some success has been attained in the Finsen Institute. It is only in those cases where there are no inflammatory edges, and no infiltration, that it is successful. The treatment is the same as that for lupus vulgaris.

The radiations given off from the Piffard Görl lamp, without the quartz covering, has been of service in treating simple epithelioma, both alone and in conjunction with the X-ray. The author has recently had experience with this lamp in treatment of epithelioma in his private practice, and at the

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clinic at the Flower Hospital, and there is no doubt that its action is good; but that it will cure many cases is more than can at present yet be stated.

Radium at present does not bear a high reputation in the treatment of malignant disease. The author is, however, convinced that the reason for this is, it has not as yet had a thorough trial. The specimens used have been of too low radio-active power, and there has been so great a fear of its destructive action on healthy tissue, that high power radium has been used too short a time. Nothing less than the so-called millionth power of German measurement should be used. The author's recent experience has been with about this strength. In one case of cancer of the tongue this high power radium was used daily for four weeks, fifteen minutes for each treatment, without any perceptible effect. The time was increased to one hour daily. On the tenth day from the beginning of the long sittings, the affected part of the tongue began to turn black. This proved to be a slough, which came off on the seventeenth day, leaving a clean base which healed over. At the time of writing, three months after, there is no sign of return.

In another case of an epithelioma of the tongue, which had been diagnosed and treated for one year as syphilis, in which there were glandular enlargements on both sides of the neck, radium was used the same as in the case just recited, with similar results, so far as the tongue was concerned; but the glands broke down about this time, and the case soon ended fatally, the tongue becoming involved again before death. These results, together with

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the success in the treatment of some other cases of epithelioma, lead the author to believe, that when larger quantities of radium of high power have been obtained we shall have a far more successful remedy for epithelioma than the X-ray.

FIG. LXXVII.

There is great promise of success in the treatment of epithelioma with radium pencils. Fig. LXXVII illustrates a case of epithelioma undergoing this treatment. Two celluloid pencils coated with 7,000 radio-active radium was introduced as seen in the illustration, and left in position forty-

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eight hours. Two days were allowed to elapse when the operation was repeated; at the end of the second period of forty-eight hours the entire mass came out, leaving a granular base as illustrated in Fig. LXXVIII. This at present writing is rapidly healing under stimulation from the ray from the Görl lamp, given for five minutes three times a week.

Very recently the author has treated an inoperable case of epithelioma of the uterus, by introducing a radium pencil of 25,000 radio-active power, leaving it in position for forty-eight hours, with the result of complete relief of pain and discharge, and a marked change in the character of the ulceration, but nothing definite can be given at this writing.

Carcinoma.—It is in the relief of carcinoma that the X-ray offers the greatest possibilities. It has not succeeded in curing a large number of cases, but that it has produced many well marked cures, now of two and three years' standing, is unquestionable; and it has improved a majority of the cases that have been treated, some of them but slightly, but others so much as to amount, in a few instances, to a symptomatic cure. This is all the more encouraging, as eight out of every ten of these cases have had every opportunity that surgery could afford them before beginning treatment, so what the X-ray did accomplish was a clear gain.

Taking carcinoma of the breast as a type, it is necessary to divide it into primary and secondary, or recurring cancer. As for the former, the same rules governing the prognosis for an operation should govern here. A quick growth having all the

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characteristics of extreme malignancy will not be

FIG. LXXVIII.

favorably influenced by the X-ray, and it will return immediately after operation. One method

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offers as much promise of success as the other. On the other hand, in very slow growths which do not exhibit signs of great malignancy there is every prospect of a certain amount of success with a possible cure. The fact that the tumor is broken down in cases of this class does not argue that a cure cannot be effected. A carcinoma in the breast of an old lady of eighty-seven years, which had a hole in it large enough to place a hen's egg, healed over, and the tumor was removed in nine months' time, the patient having taken during that period about two treatments a week.

Results in cases of primary carcinoma are sometimes striking. Nevertheless, even with such results, whenever a case is operable, it should first be operated upon, the X-ray used just as soon as the wound is healed. The success of operative measures for carcinoma of the breast is not much to the credit of surgery. The same degree of success by any other therapeutic measure would be ridiculed by the surgeons themselves. It is a question whether surgery alone is as successful as the X-ray alone, but surgery and the X-ray together give to the patient a protection which neither can separately offer. As the X-ray therapeutist is accused by the surgeon of not doing his duty to the patient if he treats a primary carcinoma when the case is operable; with just as good reason can the X-ray therapeutist accuse the surgeon of not doing his duty to the patient, if he fails to have the X-ray properly applied immediately after the operation. While, as will be seen a little later, many post-operative cases are cured after well-marked symptoms of a re-

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turn have appeared, the prospects are much better when the irradiation is given before such symptoms make their appearance. It is, therefore, most important that this should be done immediately, as soon as the wound is healed.

In secondary carcinoma the result will depend on the malignancy of the primary growth, the completeness with which it has been removed, the time that has elapsed after the operation before treatment has begun, and, if evidences of a return are present, the progress they have made.

In primary cases the author has had but one death out of thirteen cases treated, from metastasis to the pleura and lung. In secondary cases this has been the cause of death in seven out of twenty-four cases treated, and of these seven, the breasts of five had either completely healed or were in process of healing when the pleura became attacked. Of the seventeen remaining cases, one died of a secondary attack in the spinal cord and the hip joint. Five died from a general poisoning without any special distinct metastasis. Three of the remaining eleven have disappeared from observation and eight remain well, the period of recovery ranging from three years to nine months. In only one of the above fatal cases was treatment begun immediately after the wound had healed. This was the case where fatal results followed from metastasis to the spinal cord. Both breasts had been amputated, one four weeks after the other. Five cases, not included in the above, when irradiation was begun immediately after the healing of the wound, have shown no signs of returning disease. These are all

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now of over nine months' duration, and one of more than two years.

The treatment of carcinoma of the breast does not differ in any respect from the rules laid down in the general consideration of the X-ray treatment. We have here, as in other conditions, two schools, one believing in mild irradiation, discontinuing on the first appearance of erythema, and the other believing in the production of a more or less severe dermatitis, or in critical cases which show no signs of improvement, a burn. The author's belief is to follow the former in most cases, but there is danger of being too conservative for the best results. This applies to any disease treated with the X-ray, but it applies with greater force in carcinoma than any other. Chances must be taken. Do not produce a burn until all milder methods fail, and the case is yet in such a condition as to hold out some prospect of a final cure; then after due consultation with the patient, a burn might be produced in hopes of success. If, however, the prospect of final success is poor, even with this heroic treatment, it should not be attempted, as it will only add to the suffering of the patient.

A medium hard tube should be employed and placed about eight inches from the breast. The question of how much to protect is an important one. Of course, the face and parts where there is no danger of metastasis should be carefully protected, but the other breast and the glands in the axilla should receive a certain amount of irradiation. This is especially important if it is a post-operative case. If tanning occurs, and the patient's skin

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bears it well, the treatments may possibly be given daily, but, as a rule, three times a week will suffice. Eight to ten minutes should be considered a normal treatment, and only when a more heroic application is needed, should it be prolonged to fifteen minutes.

The period of time covered by the treatments will vary from three months to a year, and perhaps even longer. In primary cases success will be manifest by a shrinking of the tumor, and a relief of pain, if there be pain. The relief from pain may be out of proportion to the shrinking. In successful cases the tumor will entirely disappear, but in what has been termed in this article, symptomatic cures, there have been some nodules left, though apparently inactive, and this inactivity has remained from one to two years.

In secondary cases where there is a breaking down of the tissue, the first sign of improvement is a healthier look of the sore, which goes on to a final healing. If the recurrence is only manifest by a nodular appearance of the scar, or nodules in other places, they gradually decrease until nothing is to be found. Treatments should be continued for some weeks after all signs of the disease have disappeared.

The treatment of carcinoma in other locations does not differ from the treatment of carcinoma of the breast. The deeper seated they are, such as in the œsophagus, stomach, liver, intestines and uterus, the less probability there is of success. Yet, these deep-seated carcinomas are not necessarily beyond all hope of relief from X-ray, as a few cases have proved.

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A hard tube should always be used in treating deep-seated tumors. Generally, these internal cancers are treated through the abdominal or thoracic walls, Cancers of the rectum or uterus may be treated by the use of specially constructed tubes, or treatments may be given through a speculum made for the purpose.

Radium, which promises so much in epithelioma, in the author's experience, had but very little effect on carcinoma.

Sarcoma. Sarcoma is a disease that is readily influenced to a certain degree by X-ray, but unfortunately, this influence is not always sufficient to produce a complete cure. At present there can be no special distinction as to prognosis of the various kinds of sarcoma, whether it be spindle cell, round cell or melanotic. Osteo-sarcoma seems to have a slightly more favorable prognosis, but it is very slight, indeed. There are many cases of sarcoma that appear at first to yield to the treatment of X-ray; the tumor will decrease more or less, sometimes very markedly so; the pain is relieved and ocasionally disappears entirely; there is every indication of a successful termination, when, without any apparent cause, this favorable progress ceases, the pain reappears or increases, the tumor once more begins to grow and show signs of breaking down; the disease spreads rapidly, the general health becomes greatly reduced, and the patient goes on to a fatal termination. So often has this been the author's experience that he now looks upon signs of improvement in sarcoma as only temporary, until every vestige of the disease has disappeared.

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The conditions influencing the prognosis in general have the same bearing on the probable outcome of X-ray treatment. That there have been cases of sarcoma of all kinds cured by X-ray alone, there is no doubt. The author has had three such cases out of eleven treated, and they now remain well; one of more than two years' standing, and the other two of eighteen and fifteen months. It must be admitted, though, that the greatest use of X-ray in sarcoma is as a prophylaxis after operation, and its success here, as in carcinoma, depends largely on early application after operation.

Secondary sarcoma does not yield to X-ray treatment after there has appeared distinct signs of its returning as readily as does carcinoma, and it is, therefore, even more important that treatments should be given early in this disease. If there are signs of improvement after four weeks' treatment, hopes of a cure may be entertained; along with these hopes there is always a very large doubt, but the manifest improvement should be encouragement enough to continue treatment faithfully. If after four weeks' treatment there are no signs of improvement, or, if, after improvement has once been manifested, the disease begins once more to spread, it is useless to continue treatment longer.

The treatment of sarcoma does not differ materially from that laid down for carcinoma. The author believes that in osteo-sarcoma a harder tube should be used, and the energizing current should be greater, thus insuring a more powerful ray; otherwise the rules laid down in the general section of this work, together with the directions given

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under carcinoma, will be best adapted to the treatment of sarcoma.

In closing this chapter on malignant diseases, the author wishes to emphasize what he has already said under carcinoma, that in operable cases surgery should first be employed, and the X-ray immediately after. It is possible that a few treatments before the operation, if given cautiously, so as not to produce a condition that will interfere with healing, may also be of benefit. By this means we bring to bear the best possible methods known today for these dreaded maladies.

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CHAPTER XX.

DISEASES OF THE NERVOUS SYSTEM.

D'Arsonval's assertion that high frequency currents have no action on the nervous system, and, therefore, are of little use in treating nervous diseases, has undoubtedly influenced many workers in this field of electro-therapeutics, especially the French. The author believes this a mistake, and that future workers, relieved of this bias, will develop a large field for high frequency currents in nervous diseases in which electro-therapeutics has always held such a prominent place. Static electricity occupies an important position here, and there is no doubt that high frequency currents will reach as great a state of development.

There are few diseases of the nervous system in which static electricity may not be indicated in some way, but the diseases in which it is very important are not so numerous. It is not intended to consider all those diseases in which static electricity might, on occasion, be useful in some special developments, or in a general way, a book on general electro-therapeutics is the place for such a description. When we take into consideration the general action of static electricity, both physiological and therapeutical, it will be easy to recognize the indications for static electricity. It should always be used when a nutritive tonic is needed. It has great

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stimulating power over a depleted and reduced nervous system, and it is, therefore, indicated in all those diseases where such a tonic is needed. There are also many conditions where it may be used to combat certain symptoms, such as anæsthesia, along with other agents employed for the cure of the disease. The power that strong static sparks have in bombarding any point of obstruction to the circulation from center to periphery of nerve currents should always be thought of in that class of diseases where, from sclerosis, or other causes, the nerve current is impeded. The demonstrative effects upon the mind should also not be forgotten.

The author does not hesitate to declare, not only his strong belief in the uselessness of static electricity in those cases of paralysis where reaction of degeneration is present, but also his belief that often there may be harm done by it. Here it is that galvanism alone holds the field of usefulness. There may be cases with certain complications in which static electricity might be of value, and, perhaps, high frequency as well, but it is not for the cure of that condition which produces the paralysis.

Locomotor Ataxia.—In the earlier, or so-called congestive stage of locomotor ataxia, static electricity is very inferior to galvanism and should not be substituted for it. It is in the third, or so-called paralytic stage of the disease, that static electricity is most potent.

It is difficult to explain why these different forms of electrical manifestations affect the sclerosis in its various stages as they do, but it may be that, in the earlier stages, the changes are mostly in the circula-

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tion, and that the galvanic current has, by its action on the ganglia of the root nerves, power to affect the circulation and thus relieve the condition. In the later stages, where sclerosis has taken place, the galvanic current cannot produce very material effects, on account of its low electro-motive force. With the high electro-motive force of static charges, the shock given to the nerves produce an impression, perhaps even to the central cells. It bombards the obstruction to the free circulation of the nerve current, and helps to establish the normal nerve impulses. At present there is much enthusiasm expressed for the static wave current in long standing cases of tabes. This form of administration promises much. It has not, however, established for itself, as yet, a permanent place; but that it is one of the modalities to be considered in the treatment of this disease there is no doubt.

In order to produce the maximum effect, very severe sparks should be drawn from the spine and roots of the spinal nerves for at least three to five minutes; after this milder sparks may be drawn from various parts of the body, following down the trunks of the nerves, and especially from the bottom of the feet, where again sparks should be severe and given for two or three minutes. In fact, the treatment of the bottom of the feet, which, by reflex action, undoubtedly affects the spine and improves the conductivity of the sclerotic columns, has a great effect in temporarily relieving the ataxia.

Neurasthenia.—In neurasthenia it is important that the case should be carefully selected when high frequency currents are used. It is contraindicated

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when there is over-excitement of the nervous system. Restlessness and insomnia are contraindications of it, and it should be used only in those cases where there is complete relaxation and exhaustion without excitement and restlessness. When a patient complains of extreme lassitude, with a tendency to lie down and sleep much, auto-condensation with the effleuve or local glass electrode treatment, along the spine, will help to overcome the extreme weakness. It will give strength and vigor to the nervous system. Treatments should be given not less than three times a week, and it will be still better, providing there are no bad results, if auto-condensation be given first, followed by local treatment at the same sitting.

Static electricity, however, is of great benefit in most cases of neurasthenia. It is especially useful in traumatic neurasthenia. The author's method has been to give a general static breeze positive, negative insulation, treatments given for from twenty to thirty minutes daily, or at least every other day. Any kind of neurasthenia can bear this treatment, and will also find it soothing. In some cases when they are devoid of the extreme nervous susceptibility, the spray, or, in some cases, the brush discharge, may be given over the body, followed by sparks along the spine. This is especially useful in those cases described above in which high frequency currents are useful.

The success in neurasthenia is due more to the general management of the patient than to any special form of treatment, and any form of electrical treatment, at best, must be only a part of the general treatment.

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Chorea.—If the patient can bear a general static breeze treatment, it will be found to exert an excellent influence. Static sparks have been recommended by a high authority in static electricity, but the author's experience has been disastrous in nearly every attempt. Auto-conduction might be of use here, but experience alone will solve this point. In static application the positive breeze is given, negative insulation. The first treatment should not be given for more than five minutes, but if well borne it may be prolonged to fifteen or twenty minutes.

Hysteria.—In this disease any form of electricity will be of benefit according to its ability to build up a depleted and defective nervous system. Static electricity has here proved second to no other known therapeutical agent.

Exophthalmic Goitre. — This dreaded disease has yielded to high frequency currents. The treatment cannot be better illustrated than by the report of a case under the author's care.

A girl, fifteen years of age, came under his care suffering from a typical attack of exophthalmic goitre. She had been through nearly every known form of treatment, including an operation by which it was claimed the gland had been extirpated, but that it was removed is doubtful. The parents were desirous of having her treated with radium, as they had seen in the newspapers accounts of some wonderful cures made by this newly discovered substance. When they were informed that radium had never been applied in such conditions, but that electricity was instead, they at once rebelled. Electricity had been tried and it had failed. They were, however, finally persuaded to give it another trial.

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The treatment was such as had been followed on a former occasion with good results. The patient was placed on the condenser couch, and while the current was being applied by auto-condensation, a glass vacuum electrode, attached by means of a rheophore to the grounded end of the D'Arsonval coil, was applied over the enlargement of the gland, and over the entire cervical region. At first these treatments could not be given oftener than three times a week for ten minutes at a time, on account of the depression they produced on the nervous system. While cases vary somewhat in this respect, care will have to be exercised when treating this disease. As the condition improves, however, more frequent treatments may be given.

At the time of beginning treatment the neck measured nineteen inches, and the pulse varied from 145 to 160. Five minutes after treatment, with the patient resting quietly on a condenser couch, the pulse would always fall about twenty beats from what it was before treatments were begun, and this was not due to any fright or dread of the treatment before it was given. This decrease of the pulse immediately after the treatment argues well for a final success.

Three months after beginning treatment, the pulse was averaging in the neighborhood of 100, and the neck had decreased to seventeen and one-half inches. At the end of six months the pulse was between 80 and 90, the patient was wearing a fifteen inch collar, and her general health was very much improved. This case is of recent date, but one other treated in a similar manner, and with similar results, is now of two years' standing and

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shows no signs of returning, although there remains a weakened nervous system. In another case the treatment was supplemented by static wave current on the spine; this is now of more than eighteen months' standing, and remains in the same condition as when dismissed.

Dr. Robert Abbe has reported a case of exopthalmic goitre treated successfully by imbedding a glass tube containing a small amount of Curie 300,000 radio-active radium. The tube was allowed to remain in position for twenty-four hours, and the wound then healed perfectly normal. In four months' time the patient had so far recovered, both from the nervous symptoms and the enlarged gland, that the patient was practically well.

It would seem to the author that much better results might be expected by imbedding pencils covered with the soluble salt. Here not only the gamma rays, which are the only ones that penetrate glass to any extent, act, but the alpha and beta, as well as the emanations, would affect the parts.

Hodgkin's Disease. Pusey and others have reported cases of Hodgkin's disease cured by the use of the X-ray; the author has also seen two cases greatly benefited by its use. The treatment employed was to irradiate the enlarged glands. The irradiation was never carried further than to produce a mild erythema. With the disappearance of the enlarged glands, hemoglobin increases, and the red corpuscles also, but to a less extent than the hemoglobin. It appears, however, that the cures are not always permanent; the legitimate use of the X-ray in this most dreaded disease is as an adjunct to other well established therapeutic means.

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